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SCHOOL SCIENCE

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FOUNDED BY C. E. LINEBARGER

A Journal
for all
SCIENCE AND
MATHEMATICS
TEACHERS

CONTENTS:

ON TO CINCINNATI

November 26th and 27th will be days of inspiration and pleasure for the large group of science and mathematics teachers who will attend the 37th annual convention of the Central Association of Science and Mathematics Teachers to be held in the Netherlands Plaza Hotel in Cincinnati, Ohio. Every subscriber to SCHOOL SCIENCE AND MATHEMATICS is eligible to membership in the Association at no extra cost and is urged to take advantage of this opportunity for professional growth.

President W. R. Teeters reports that the Cincinnati people are doing a wonderful job and he is sure that this will be one of the finest meetings that the Association has ever had. On Friday and Saturday mornings, there will be programs of general interest to the teachers of science and mathematics. On Friday afternoon, the Biology, Chemistry, Elementary Science, General Science, Geography, Mathematics, and Physics sections will meet in the various rooms at the hotel and in each will be presented a program of special interest to the group.

Many teachers in the high schools and colleges in this country attribute a great deal of their success to the help and inspiration that these meetings have given them. Professionally, there is an opportunity to listen to authorities speak on the latest developments in the fields of science and mathematics teaching and on the findings of research that is being done in the fields of pure science and mathematics. Ideas are exchanged with fellow teachers at the meetings and in the informal discussions that take place over the luncheon tables and in the lounges. Friendships are established which are kept alive by

correspondence, by contributing to the Journal, and by attending conventions or section meetings.

Cincinnati is easily accessible by road or rail from any city in the middle west or east. It is a city which is known for its clean municipal government, its citizenry which has progressed in spite of floods and other obstacles, and for its location on the Ohio River which is rich in natural beauty and in lore of early pioneer days. The Thanksgiving vacation period can be one of rest and leisure as well as one of growth and enlightenment if you spend it in Cincinnati.

Decide now to attend the convention. If you are not now a member of the Association and wish to become one, or wish a printed program of the convention to be mailed to you, or wish any other information in regard to the Association, please write to me at the Oak Park and River Forest High School at Oak Park, Illinois.

<div align="right">

HAROLD H. METCALF
Secretary

Central Association of Science and
Mathematics Teachers

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THE RADIUM FAMILY TREE

Radium traces its ancestry back for billions of years. Its great, great, great grandfather was uranium, heaviest of all elements. Uranium (92) resembles tungsten and hence is placed in the sixth group of the condensed periodic table.

And Uranium lived 5 billion years and, giving up an alpha particle, begat UX_1, isotope of Thorium (70). And UX_1 lived 25 days and, giving out a beta ray, begat UX_2 (91). And UX_2 lived but a minute and losing a beta ray, begat UII (92). UII was the exact image of his great grandfather Uranium I. And UII lived 2 million years and (losing an alpha particle) begat Ionium (90). And Ionium lived 70 thousand years and (losing an alpha particle) begat Radium (88).—John A. Eldridge, *The Physical Basis of Things* (McGraw-Hill Book Company).

PHONE BOOTH

A telephone booth without a door, yet without a disturbing sound, is on exhibition at the Museum of Science and Industry in Chicago.

Engineers, seeking to avoid an "unwanted Turkish bath" or disturbing noise for the user of the public telephone, have devised a doorless booth which is made quiet by liberal use of sound absorbent material in its construction and is kept cool by perforations in its sides. The sound absorbent material creates a "zone of quiet" inside the booth.

A metal lining for the booth increases ease of keeping the booth clean, and discourages pencil-scribblers, it is said.

MARINE AQUARIA

By John H. Welsh, *Biological Laboratories*
Harvard University, Cambridge, Massachusetts

Nowhere is there such diversity among animals as there is in the sea. Certain groups such as the echinoderms, to which starfishes and sea urchins belong, are found only in the sea. The coelenterates have very few representatives in fresh water. Many of these marine animals are much more colorful; much more interesting in their habits than their cousins who live in our ponds and streams or on the land. The entertainment and
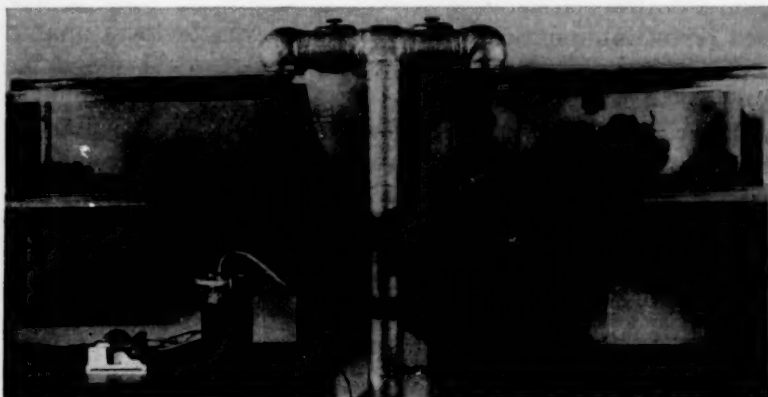
instruction provided by a group of hermit crabs; the problems in locomotion presented by the starfish; color changes in our common killifish or Fundulus (which have been more widely studied in this than in any other single fish) are but a few of the reasons for a growing interest in salt water aquaria.

Many inland schools and colleges now purchase each winter a marine set from one of the biological supply houses where such sets are offered. This includes representative animals and enough sea water so that with the proper care the animals may be kept alive for weeks and months, and may be studied by students who would otherwise know them only as pickled specimens. An increase in the number of inquiries from individuals who wish to start salt water tanks shows that the possibilities which they offer are beginning to be appreciated.

It was not the purpose of this article, however, to create added enthusiasm for marine aquaria, but to present briefly

some of the things the author has learned about their maintenance, most of which was gained in developing a set of display tanks for our own biological laboratories. The accompanying photograph of these tanks needs but little explanation. The aquaria are of twenty-five gallon capacity and their frames are of stainless steel, which is a very satisfactory metal to use around sea water. The filtering and aerating systems are well known to readers of aquarian magazines. There are other filters and filter pumps which would doubtless be just as satisfactory, but this set functions well and is so constructed that no metal comes in contact with the water.

The pipes which occupy the center of the photograph are from a central refrigerating system through which brine is carried for maintaining the water at a low even temperature. A cooling system is not absolutely essential and would seldom be possible without undue expense.

These aquaria have been in use for nearly two years and although the animals were removed during the summer and replaced with fresh ones in the fall, the sea water has not been changed. At the present time the crabs, starfishes, sea anemones, snails, clams, barnacles, Fundulus, and bright green Ulva or sea lettuce are thriving and always available for observation.

In experimental laboratories the old motto "live and learn" might well be changed to "live and relearn" for many of the facts which are discovered daily are simply rediscoveries and the following suggestions are offered not as new ideas but old ones which need frequent emphasis. Perhaps the most important single factor in determing the successful beginning of a marine aquarium is the proper aging of the sea water. This is a point to be remembered in starting fresh water aquaria, but is much more important in the case of salt water. Although artificial sea water may be made it is better to obtain real sea water from an uncontaminated source. This may be diluted with fresh water, using one part of fresh to three parts of salt, for most of the littoral or shore animals do better in such a mixture. After the aquarium has been arranged and filled with this mixture it should stand until the water is crystal clear before animals are added. This may take two weeks or longer depending on how much organic matter and bacteria were originally in the sea water. If a filtering system is to be used, such a long wait is not necessary. Next in importance is either a low tem-

perature or aeration, or both. There are very few marine plants which will thrive in an aquarium and these produce little oxygen; hence if a reasonable number of animals are to be kept it is necessary to furnish them the oxygen they need either be lowering the temperature, which permits more to go into solution, or by aeration. Our tanks are maintained at a temperature of 15°C or 59°F, which is quite satisfactory for animals from Massachusetts Bay, as it is a good compromise between winter and summer temperatures in the bay, and it allows much more oxygen to stay in solution than would be possible at the usual room temperature of 21°C. At the same time organic decay and the growth of bacteria are appreciably reduced; hence it is not necessary to be on a constant watch for uneaten food. A suitable low temperature may be maintained during the winter months by placing an aquarium against a window. Most metals are acted upon by sea water and as the products may be highly toxic it is essential that such metals as copper and zinc, or any alloys containing these, be kept out of contact with the water of marine aquaria. Lead soon forms an insoluble oxide on its surface and is quite safe after this oxide has formed. Pipes which are used to conduct sea water for aquarium use are usually of lead. The chromium plating of brass is unsatisfactory if the coating is thin as the sea water may penetrate and slowly dissolve the copper in the alloy. The thermo-regulator which we use to control the valve in the brine system, hence the temperature of the tanks, was plated with chromium but finally it was found necessary to enclose it in a glass tube which keeps it out of direct contact with the water.

The ease with which Artemia or brine shrimp may be raised now makes it possible to keep some marine fishes such as seahorses, which previously were difficult to maintain; but the majority of the inhabitants of a marine aquarium prefer chopped clams, shrimp, or bits of uncooked fish. Starfishes prefer to shuck their own clams or oysters, if they are not too large, and the process is an interesting one to observe.

The information contained in this article may not be all that is essential for the successful maintenance of a marine aquarium, but the important requirements have been noted and the rest may be learned by experience.

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

INTEGRATION OF PERSONALITY EVOKED BY PANDEMIC CHEMISTRY*

By Ernestine M. J. Long

Normandy High School, St. Louis, Missouri

For some time administrators, secondary school teachers, college professors and faculties of nursing schools have not known how to meet the needs of pupils in terms of personality integration. The vast majority of pupils leaving public high schools enter the business world and make homes. Curricula in most institutions are designed to prepare pupils to enter college. Subject matter has been stressed; scientific methods of thinking have been taught in a few schools; character education is more or less a trial and error procedure and is even taboo in some districts. Quite a few teachers have wondered how you could teach Maurice to balance chemical equations when part of his mind was on a sick father in the hospital. Elements of disintegration and distraction abound on all sides.

One of the great mysteries of life that harass most organizational workers is to know how people can be trained to shoulder responsibility and become leaders. There certainly are not enough sufficiently trained intelligent leaders to man our Ship of State from the state government on down. One day at the polls would convince any citizen that there are not many well trained followers. If our democracy is to survive, we science teachers must break the old subject matter molds that have bound our thinking until it has become moldy and in the language of young America "get going." We must discover new ways and means of integrating the personalities of our pupils.

Charles Judd (1) recently produced some nuggets of wisdom that will bear repetition.

The cure for industrial chaos is intelligent adaptation of individuals to the conditions which surround them. Such adaptation is possible only when education has prepared individuals to solve problems through the exercise of analysis and reasoning. If there was ever a time when education ought to be in a position to help individuals to cope with the problems of life, it is the present when individuals need to be guided in their attitudes and behavior by ideas far broader than those which were adequate when life was chiefly concerned with the manipulation of the visible and tangible objects of the immediate environment. . . . Individuals become truly educated when they learn how to use recorded knowledge for the purpose

of forming independent judgments. . . . Above all, men must cultivate a comprehensive intellectual grasp of all the elements which enter into the social complex and must develop the power of constructive thinking, which is the highest expression of human intelligence. . . . The only hope for international unity is the education of the peoples of the world in the ways of cooperative living.

A survey at Normandy revealed that less than 20% of the chemistry pupils entered professional schools. It did not seem fair to train 80% of the pupils to meet just college requirements. A revision of the curriculum was in order. It was felt that a course could be devised that would meet the needs of college preparatory pupils, and those going into business or home making.

Stimulated by work under Downing and Davis and driven into action by pupil needs, a pandemic chemistry course for secondary schools was constructed.

Recognizing the importance of work by Tyler (2) and others, but lacking time to construct tests to properly evaluate findings, *Living Chemistry* (3) was written from the point of view of a general practitioner in science teaching. Next summer a more scientific approach will be made with no doubt many revisions. It was felt best to take chances intellectually and act on available evidence so that action would not be paralyzed and negative thinking enter.

PHILOSOPHICAL BACKGROUND

There are many definitions of integration but for all practical purposes integration is achieved when the pupil reacts as a unit to any stimuli in his environment. It means that the stimuli must capture him physically, emotionally and intellectually. One Science Committee on curriculum revision (4) reported "The individuals' behavior is integrated when it can be said of him that: he is guided by deep conscious purposes and is able to see their broad implications."

Recognizing the importance of integration and sensing the tool value of science as an organized body of knowledge, the construction process began. Many controlled attempts to integrate the personality through curriculum revision have partially failed even under ideal conditions.

The instructor decided to become a guinea pig and began to discover ways and means of better integrating her own personality. The theory was that all the curricula revisions and the products of brilliant minds working days on end would never

be able to put Humpty Dumpty together again unless the teachers changed and became integrated personalities.

It was decided in the face of criticism and some slight ridicule to create a cultural course in chemistry in a public consolidated school with children coming from Pasadena Park and Toad Lane on the border of Hell's Halfacre.

Hopkins (5) has so beautifully described the cultural course that was to be the goal. "A cultural course must then, develop not merely an appetite for intellectual attainment and moral excellence but it must contribute definitely toward open-mindedness, sincerity, an active interest in social betterment, and a productive participation in all enterprises which have as their ultimate goal the uplift of humanity. . . . The deciding factors are determined by the method of approach, the purpose for which the subject is studied, and the general attitude of mind which is carried away by the students themselves."

THE APPROACH

After five years of experimentation and a critical study of research work in the field of curriculum construction, it was decided to divide the year into nine units of work. The Morrison Unit Plan of organizing material was used. Special teaching techniques were devised for some of the units. Interesting unit titles to suit the new stream-lined American youth model were: "In Action with Hydrogen, Diving in for Ions, Nosing out the Non-Metals, Why Figure?, On the Trail of the Electron, and Chains and Rings of Carbon Atoms." The youngsters suggested some of these titles unconsciously in their work.

Never more than seven major unit understandings were constructed for each unit. Often the number was less. Certain concepts necessary for mastery of the understandings were determined. The subject matter of chemistry was dignified or perhaps desecrated (depending on the school of thought you belong to) and was used as a tool to train pupils to think scientifically and throw safeguards around their thinking. The subject matter was sometimes arranged to focus conflicts in thinking and to develop certain emotional standards. The course of study was designed to teach the subject matter and philosophical understandings related to chemistry. It was believed that if young people's experiences were really educational that they would result not only in a knowledge of the subject matter but in constructive attitudes and changed behavior.

Most of the unit material was presented to the pupil in a disorganized state. After reading the unit, text and experiments, the pupil made out a day by day assignment for himself and organized his own work. There were frequent consultations with the teacher. Many of the units were so organized that the pupil was forced to use a scientific method of thinking with safeguards to arrange the time budget plan for the unit. Experiments were devised in which the pupil consciously used scientific methods of thinking with safeguards. Every effort was made to make the pupil intellectually and emotionally independent.

Lectures were woven around subject matter and philosophical understandings. Each unit contained appropriate subject matter understandings, one method of scientific thinking with safeguards and one emotional standard.

The scientific methods of thinking were adapted from Downing (6). The emotional standards were the product of interviews held with scientists, and the teacher's subjective judgment regarding attitudes and qualities which would be necessary for success in the field of science.

Efforts were made to encourage pupils to take part in community activities especially where certain of the emotional standards and scientific methods of thinking came into play.

A definite attempt was made to capture the passionate enjoyment of work that so characterized the work of Liebig at Giessen. Cannizzaro in 1872 said, "It often happens that the mind of a person who is learning a new science has to pass through all the phases which the science itself has exhibited in its historic evolution." This was recognized and in some units, situations were created to enable the pupil to live through historical incidents in chemistry.

The teacher saw the need for change. As Philip Cabot once said, "What is needed is not so much the strengthening of the curriculum as of the staff, for whatever the name of the course of study, the objective is always the same—namely, to teach a way of life. Men cannot teach what they do not know." A self-analysis revealed that the teacher was cold, critical, analytical, self-righteous, fearful and intellectually proud. It was discovered that fear as a beginning teacher had been repressed over a period of years and drove pupils away. The very next day after that was brought into the conscious state and surrendered, pupils came up for help in droves. The barriers fell.

Many other improvements in the teacher-pupil relationship grew out of another device. The moment a high tension area came up between teacher and pupil, the teacher analyzed the situation, sought her own error, went to the pupil admitted the wrong and made it right. It was found to be very effective in reducing the teacher's intellectual pride.

The teacher began to live Lyman Newell's vow (7)

I will see the good in all pupils and lead them to higher attainments.
I will be patient and forbearing, confident in the belief that kindness and generosity will ultimately triumph.
I will scorn error, deceit, and all forms of falsehood, persistently foregoing sarcasm and injustice.
I will claim all nature as my heritage and spend a portion of each day quietly in God's open air.
I will hold daily communion with my own soul.
I will accept my remuneration, however small, without envy, complaint or discouragement, never forgetting that a teacher is a leader into the higher life and not merely a wage earner.
I will work each day in unshaken assurance that peace and power come in full measure to all who are ready for the truth.

With some modifications, pupils were encouraged to do likewise.

Mature students were encouraged to rise early in the morning and spend time in doing some constructive thinking and communing with their God if they believed in one.

RESULTS

Although the school enrollment did not increase proportionately, the enrollment in chemistry doubled and tripled in two successive years. Failures were markedly reduced. One semester the failures were as low as 2%. Pupils going on to college have had no difficulty. In fact some of them have been very successful.

Pupils developed initiative and originality. They developed a sense of humor that often carried them through the long, weary desert periods of balancing equations and doing chemical mathematics problems.

The desire to make discoveries was intense. One girl found some equations in a copy of Gray Sandifur and Hanna in the room library. Two weeks before such things were mentioned in class, she wanted to be introduced to the mysteries. After some explanation, equations were worked. With one hand on my shoulder, peering over, she said, "That is a lot like algebra. Boy this is fun! 'Joy in making discoveries!' I'm going to like this."

A kitten strayed in the laboratory and into a box of odds and

ends. One of the purposefully observing boys remarked, "Look, kitty has scientific curiosity too. It wants to make discoveries." Those of you familiar with the anecdotal method of evaluating teaching results will recognize the importance of this method and also the complete case study method.

B—— came from a nice home. His father and mother were separated. He lived with his mother in the home of his grandparents. He was given everything he wanted. He was an only child and had been teased into an inferiority complex by neighbor children living on the block. He was fearful and uncertain of himself. On entering high school he became a bully and soon incurred the dislike of teachers and pupils. His isolation drove him to work in a home laboratory on experiments. He became the school problem.

He began to fail in chemistry after a fair start. One day he heard the teacher mention something about social and political issues. In a conference after school he poured out his views on communism and political science.

The teacher listened. At the end of the interview he wanted to know what had caused the teacher to change so much from the year before. He was told why. He went to his German tutor admitted a lie and asked forgiveness. He began to use early morning periods for self-analysis and creative thinking. He became less demanding at home. His relationships with other pupils improved even to the acquisition of a girl friend. Every time he ran afoul the faculty, he admitted his wrong and made it good. His grades went up from low to very high. He maintained the record for the remainder of his high school career.

B—— became concerned over dishonesty among the students. One morning he produced a questionnaire (the product of a morning time of communion) on honesty and suggested that the teacher might want to use it. The questions were prepared to test the consistency of thought on the part of pupils regarding the subject of honesty.

The questionnaire was given to pupils. The results showed that pupils were not consistent in their views on honesty. A question was formulated on an examination given pupils: "The answers on the questionnaire 'On Being Honest' were inconsistent. Outline a policy which could be used in this school to correct such a situation." The answers if followed would bring about a change in any system if one had the courage to try them. It was so good that it was decided to compile the re-

sponses and present them to the school at an auditorium session. Heated discussions arose in the locker rooms with B——doing a yeoman's job upholding the cause of honesty.

Later a prominent woman spoke at the Mother-Daughter Banquet on honesty in government and explained the Merit System. Thus honesty was tied up with political affairs in the community.

In his senior year B—— became a real social force. The senior class debated what sort of gift to give the school. They decided on shrubbery. B—— felt that they really had not done any constructive, social thinking on the subject. The product of another morning's period of reflective thinking was the idea of a public address system of amplifiers for the auditorium and campus. It staggered the senior class! One hundred fifty-four of them had labored but none had produced such a colossal idea as that.

Where was the money to come from? B—— the streamlined model who liked modernistic furniture and architecture went to the School Board. The Board has always done its best, but Normandy is a poor district and usually every expenditure is eyed with great caution and pared to the bone. It has been a necessity. No one knows how B—— put it over or exactly what he said, but the Board matched the senior class's money, and Normandy has a public address system that functions inside and out. The story drifted back that B—— had put a large lump of his own savings into the enterprise. Thus a self-willed, spoiled boy became an integrated personality and a social force. It started in a pandemic chemistry course. Changed teachers make changed pupils. The subject matter must be stressed, but as a tool, a means to an end and not the end itself.

Pupils vary in the degree in which they become integrated personalities. A warning must be sounded not to push them ahead too fast and expect adult behavior. If standards were set too high, strain entered, and the desire to integrate was lost often for two-year periods. The importance of the teacher's sensitiveness, alertness and degree of personality integration was at once apparent. The change had to start with the teacher.

The spirit of cooperation and pure joy was most stimulating. There has not been 100% integration of personalities. Some failures have resulted from outside influences. Attempts were made to change home conditions. Some of these failed. In some cases the pupils were glandular cases under doctor's care. In

such cases, it has been found best not to focus the attention of the pupil on emotional conflicts. In most cases in which integration did not take place in terms of changed behavior and performance, the teacher slipped and tension areas arose. They were never violent and often were subconsciously buried in the pupil's mind. It was felt that some of these cases might have responded to definite treatment had there been more time.

The Downing Test for Scientific Thinking was found to be a useful tool in measuring scientific thinking growth. A report of the validity and reliability of this test will be made later. Just now it is fair to say that it is useful. Last year three-fourths of the pupils gained in their ability to think scientifically as measured by the Downing Test. Some gained as much as $37\frac{1}{2}$ points, although an increase in grades did not always take place. Grades were based largely on mastery of the subject matter. The contract plan of fixed minimum essentials was used along with optional work. All subject matter examinations were of the objective type but have not been standardized.

Grades as a whole have steadily increased. 1935–36 showed an increase of 22% over 1934–35. The I.Q.'s have not perceptibly changed.

SUMMARY

1. A pandemic chemistry course for high school pupils was constructed to correlate subject matter understandings and philosophical understandings, that is, scientific methods of thinking with safeguards, and emotional standards.

2. The course of study evoked personality integration in the majority of pupils and was evaluated by the case study and anecdotal methods in terms of changed behavior.

3. A changed curriculum administered by a changed teacher produced changed pupils.

4. Chemistry was found to be a ready tool to use in developing methods of scientific thinking and broadening the pupil's view thereby making him cooperative and a social force.

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STAMPS THAT TEACH CHEMISTRY

By BARBARA FULFORTH, *Philadelphia, Pa.*

In the May, 1934, issue of the *Journal of Chemical Education*, Professor Harold F. Schaeffer, of the Waynesburg College, introduced the theory that philately serves chemistry. Being a stamp collector and chemistry student, I decided to test this idea. My teacher was very enthusiastic and offered to aid me in case any difficulties should arise. I set about trying to find the suggested stamps and also found many more that could be used. These stamps are very inexpensive, few costing as much as fifty cents. The stamps were mounted on a large sheet of bristol board with explanatory remarks printed beneath each one. A cellophane covering protected them from being soiled and damaged. The students in the class grouped around them, anxious to see pictures amplifying what they had been studying. Later the chart was put where everyone might see it,—not only the chemistry students, but anyone who might be interested.

This chart served me in two ways. First, I found many unusual stamps that could be proudly placed in my collection. Second, it brought to my attention many additional facts of interest in connection with chemistry. This helped to impress on my mind, more vividly, work studied in class, as it has been noted that what one sees makes more impression than what one hears.

There are stamps relating to the early days of alchemy, some commemorating men famous in the field of chemistry, while others show the elements, their extraction and application. For instance, we find stamps depicting the Pyramids and the Sphinx, time-worn relics of antiquity, which saw the dawn of alchemy. The commemorative stamps of France honor such of her great sons as Pasteur, Berthelot and De Rozier. From Netherlands, we obtain the stamp in honor of Boerhave, an early chemist. Italy has issued stamps bearing the pictures of Leonardo da Vinci and Alessandro Volta. Even Russia has a stamp on which appears the likeness of Michájlo Lomonósov together with the picture of the Russian Academy of Sciences. Ireland has a stamp on which a hydroelectric plant is shown. An issue of stamps from Chile celebrates the importance of the nitrate industry. Norway has issued a stamp in tribute to the application of radium, one of the more modern elements, the stamp displaying a hospital of radiumtherapy. One of the Saar Valley stamps provides us with a good picture of a colliery shaft head and another, with a man holding the Davy safety lamp. The sun, where helium was first discovered, may be found pictured on a Persian stamp.

Stamps also portray conceptions of Gods of Mythology for whom elements have been named. Mazda is found on a stamp from Iraq; Toth appears on an Egyptian stamp, while Mercury is found on Greek and Chinese stamps. Silicates, dyes, drugs, gems, all types of chemicals and innumerable processes are represented somewhere among the stamps. However, one must be alert to recognize issues of chemical significance as many have no labels or title.

HOW MUCH PROGRESS IN SECONDARY SCHOOL GEOMETRY?

By Jos. S. Butterweck

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How well is secondary school practice keeping abreast of secondary school theory? Is the gap becoming wider or is it gradually closing? Are our schools making needed changes or are the controlling influences of tradition and vested interest too strong? What is the situation regarding plane geometry? It is pretty well entrenched in the secondary school curriculum. This fact can be established by examining the biennial reports of the Federal Office of Education.

In 1910, 31% of the total high-school enrollment was subjected to the study of plane geometry—283,000 of the high-school youth of a generation. In 1928 the ratio had dropped to 20%; but with an increase in secondary school enrollment from 915,000 to 2,189,000 in those eighteen years the total then studying geometry reached well beyond the 400,000 mark. What the total is today we do not know, but with an increase in secondary school population to 7,000,000 the chances are that the number exposed to plane geometry has not decreased.

Does its contribution to youth justify its position? Should it undergo drastic modification? If so, is such modification possible or will the needed changes result in an entire elimination of it? Would such an elimination exclude a form of mental training essential for the development of youth?

During the past fifty years educational theory has traversed much territory. From Herbartian apperception to the "school is life" philosophy of John Dewey; from an emphasis on the acquisition of subject matter to an interest in the individual; from intellectual growth as the sole measure of achievement to well integrated behavior—social, physical, mental and emotional—such progress seems millennial.

Nor has psychology failed to keep pace with philosophy. Faculty psychology has given way to "gestalt"; the belief that a small part of the brain is the seat for particular behavior has been supplanted by the claim that every part of the organism responds to and is affected by a stimulus; mind and body dualism is replaced by mechanistic monism; the stimulus and response Thorndikianism has given way to the thought that both

stimulus and response are part of the same configuration and each is constantly being changed by the impact of the other. The approach to the whole through the sum of its parts has been replaced by the integral characteristic of the whole, independent of the nature of its parts.

So much for philosophy and psychology. How much have these changes affected school practice? This answer, no doubt, depends on the point of view from which we evaluate practice. Shall we refer to the reports and recommendations of the National Association of Mathematics Teachers? Shall we visit Lincoln School or other schools known for their progressive tendencies? Shall we take a large sampling of practices in the conventional secondary schools throughout the country? Obviously the first method gives us theory rather than practice; the second is not typical; the third requires too much labor before we have accumulated sufficient data to have a reliable cross section of prevailing practice.

The most important single device used by the teacher in the American secondary school is the textbook. It is often the teacher's sole prop. It becomes the syllabus to which the teacher refers when he wants to determine the year's work ahead of him, the bases for the assignment to specific tasks which are daily imposed on the pupil, and the outline which he consults when preparing the examination with which he measures the pupil's success. Changes which have been made in the textbooks during the past hundred years would, therefore, become the most valid single measure of progress in teaching a particular subject.

I shall use 33 geometry textbooks selected at random from a textbook library. The oldest of these was published in 1826 and the most recent in 1932. For the sake of convenience they have been divided into five groups. The grouping is largely arbitrary although date of publication is the basis for the divisions. In deciding upon the lower and upper limits of each term period, I had in mind certain social and educational movements which have affected the secondary school problem.

A. Before 1880 (5 textbooks): Secondary education was primarily college preparatory, for the select few, largely a private venture and little influenced by the educational theory growing out of Rousseau's philosophy.

B. Between 1880 and 1900 (6 textbooks): A secondary school attended by the masses had its real beginning. During

this period the conflict between a curriculum growing out of the expressed need of the masses versus the desires of the few was won by the academicians.

C. Between 1900 and 1915 (4 textbooks): A secondary school attended by the masses became an established fact. Herbartianism developed a consciousness of method. "Fads and frills" were taking form.

D. Between 1915 and 1928 (14 textbooks): War psychology and mass production were the large social forces. Thorndikean psychology and the scientific method affected educational practice. The junior high school came into being. The N.E.A. reversed itself by substituting the seven cardinal principles report for the 1893 report of the Committee of Ten.

E. Since 1928 (4 textbooks): The social changes growing out of the Depression have developed a growing consciousness of the futility of our educational system. Secondary schools begin to recognize the need for developing an individuality. Experimental programs are undertaken to throw off the college yoke. The Dewey philosophy is being injected into secondary school theory.

One should expect that these social forces and the changes in educational philosophy and psychology would be reflected in the textbooks which become the teachers' prop, and the pupils' main intellectual diet. What are the facts?

I. METHOD OF INTRODUCTION

As one turns to the first pages of Wentworth's Geometry (1899) one is confronted with a series of definitions of terms such as surface, point, dimension, solid, geometrical figure, proof, theorem, corollary, converse, straight line, rectilinear figure—80 of them, filling 14 pages. Wentworth instructs teachers as follows: "It is intended to have the first fourteen pages of this book simply read in the class, with such running comment and discussion as may be useful to help the beginner catch the spirit of the subject matter and not leave him to the mere letter of dry definitions."

These definitions are placed together in the first chapter on the assumption that they are essential knowledge before the pupil can deal successfully with geometric principles. In other words, knowledge must precede action; that is, the elements of a whole must be learned before experience with the whole should

be undertaken. We shall not at this time examine the validity of this assumption; we shall simply state it as a necessary implication in a textbook organized as Wentworth's is arranged.

How do our other 32 textbooks compare in this respect? All but one have the same type of introductory material. The amount of space devoted to this treatment varies; the type of definition used differs among authors; the quantity and quality of the illustrative material employed to give meaning to the definitions give uniqueness to some of the books. But with one exception, all assume that the budding geometrician must begin with definitions.

If we compare the earlier textbooks with the later ones, the following conclusions result:

1. The amount of space devoted to definitions increased from 5 pages in 1826 to 40 in 1932, or from a median of 10 among the books in group A to a median of 31 in group E. The medians for groups B, C, and D are 17, 27 and 22 respectively.

2. The increase in space devoted to definitions is due not to an increase in number of terms defined, but to a more elaborate manner of impressing these on the pupil. Pictures, drawings, applications to life, are employed freely in those devoting the greater number of pages to definitions. Skyscrapers, bridges, Egyptian pyramids, snowflakes, honeycombs, spider webs, Pueblo houses, clocks, sundials, butterflies—embellish the pages and add interest to the reading.

3. With the exception of the first group (published before 1880) both methods of introducing definitions are used. One published in 1896 introduces mensuration and intuitive geometry to the tune of 39 pages; another published in 1912 devotes 65 pages to definitions, constructions and applications to surveying; 2 texts published in 1929 and 1931 use 22 and 18 pages, respectively, with little pretense at practical application.

4. The life on which the author drew in order to amplify his definitions has become broader in recent years. During the period of 1880 to 1914, mechanical drawing and surveying were the primary applications; in recent years all of life surrounding the pupil has become an appropriate application. From the design of the nature-made snowflake to the man-made skyscraper, from the bicycle which is the pupil's daily companion to the Egyptian pyramid which he will probably never see in reality, all are drawn upon to convince him of the omnipresence of geometry.

II. ORGANIZATION

Wentworth recognized the existence of 5 groupings for plane geometry. These he referred to as Books. Book I concerned itself with Rectilinear Figures. Subsequent Books dealt with the Circle, Proportion and Similar Polygons, Areas of Polygons, and Regular Polygons and Circles.

All the textbooks in our A Group (published before 1880) use essentially the same organization, although the number of such divisions or Books varies from 4 to 8. This difference is due simply to a finer division than that used by Wentworth, rather than a different organization. The six texts in the B group use a similar organization, although one refers to these divisions as Sections rather than Books and another calls them Chapters.

Between 1900 and 1914 no change in organization is evident; in fact each of the four texts in our study division contains 5 Books. Since 1915 there has been a tendency to substitute Chapter for Book, 6 of the 14 texts included in the D group using such a connotation. One text published in 1932 uses the term Unit in place of Book or Chapter. The influence of Morrison's unit organization and mastery technique seems evident; at any rate the author is trying to follow a terminology which is popular today. Upon closer examination it becomes clear that a term has been used without knowing its meaning. For example, the introductory chapter devoted to definitions and principles is called Unit I. What is commonly Book I has been called Unit II. The subdivisions of Unit II are called topics. Topic 1 is Congruent Triangles; Topic 2, Parallels and Perpendiculars; Topic 3, Sums of Angles in Triangles and Polygons.

The same author published another text the same year. There are two differences between these texts; one has a red cover and the other a green cover; one refers to Units and Topics, and the other drops the term Topic and refers to each subdivision as a Unit. Apparently a change of name of the division and color of the binding has created a new text worthy of the public's attention.

III. EXERCISES USED

At the end of each Book Wentworth included many exercises intended as applications of geometric principles discussed in that Book. How do other texts compare with that of Wentworth?

Texts published prior to 1880, with one exception, employ

little or none of this learning technique. One text published in 1865 on the other hand has a rather large number of exercises which serve as applications of geometric principles to life. For example, "A ladder 65 feet long is placed against a house, so that its foot is 25 feet from the house. How high does it reach?"

Each group of texts contains some in which such exercises are numerous but with little or no application to life, some in which the exercises are few or lacking entirely, and some in which the exercises are numerous and deal with practical life situations. The tendency toward the last type of text is greater in the more recent texts. For example, 5 of the 14 in the D group and 3 of the 4 in the E group are definitely of this type.

IV. HISTORICAL REFERENCES

The adolescent is interested in adventure, in pioneering, in hero worship. Some of the stories of mathematical discoveries are replete with the spirit of adventure. Their introduction in a geometry text ought to add interest to the reading. To what extent do authors avail themselves of this fact?

Fifteen of the 33 authors employed this learning aid: 1 in group A, 3 in group C, 8 in group D, and 3 in group E. The amount of this use varies from incidental references to Archimedes, Euclid, and the like, to devoting 10 pages to a history of geometry.

To regard this as a modern practice is to leave out of consideration the fact that the text published in 1865 contains an interesting 4 page reference to historical material.

V. METHOD OF PROOF

Nearly all textbooks adopt the conventional syllogistic proof. The variations are only in the amount of help given the pupil; namely, the extent to which the text is an aid to memorization rather than an aid to thinking. Two propositions were examined in each text to discover the tendency of the authors in this respect. One of these propositions was relatively easy and required no construction lines to complete the proof; the other was relatively complicated, involving the use of construction lines.

There is a slightly greater tendency to omit the syllogistic proof in the more recent texts or to substitute hints and suggestions or insert the question "why" in place of the reason for the statement. Nine of the 14 texts in group D use this technique

to help the pupil to independent thought. It is worthy of note, however, that three of the four texts in the more recent group resort to the detailed syllogism for the more difficult proof. Two of the four depart only slightly from this practice for the easier of the proofs studied.

VI. AUTHORSHIP

College professors of mathematics, public as well as private secondary school teachers of mathematics, and professors engaged in the training of teachers, are numbered among the authors. None of these types of teachers preëmpted the authorship of geometry texts of any period. There is, however, a tendency for some to be more prominent at certain periods in the last century. For example, 3 of the 6 texts belonging to group B were written by those engaged in teacher training; 4 of the 5 published in the C group were written by high-school teachers; 13 of the 14 comprising group D were written either entirely by or in copartnership with secondary school teachers; the 4 published since 1929 had the high-school point of view represented in the authorship; 3 teacher training representatives were included among the 1915–22 publications.

In addition, coauthorship has been becoming more common in recent years. Only 2 of the 15 books published before 1915 had more than one author, and in these coauthorship was drawn from the same professional level, high-school teachers of mathematics. Since 1915, 7 of the 18 books were written by 2 or more authors, and 6 of these represented more than one of the three mentioned professional levels.

It is difficult, however, to observe the effect of increase in number of authors or professional level of authorship on the quality of the text produced, with one exception: i.e., those authors who were connected with the training of teachers in the earlier periods (before 1900) seemed to have produced textbooks which contained a larger number and a greater variety of learning devices than others published during the same period.

Four of the more recent texts (since 1915) were written by teachers of secondary schools reputed to be progressive. With one exception, no unique qualities are discernible in these texts.

There is one question which we are trying to answer in this study: Has the teaching of geometry undergone sufficient

change to warrant its inclusion in the secondary school curriculum to the extent to which it is being studied today?

A hundred years ago the secondary school existed primarily for college preparation. It was attended by a very small percentage of the youth of this country. As a rule only the intellectual elite enjoyed its advantages. Education was then regarded as a mental discipline. Faculty psychology was the order of the day. The knowledge of the ages was regarded as the appropriate subject matter to achieve this discipline. A logical organization of this knowledge by the scholar was supposed to provide the best means to achieve this end. He who had learned, reflected about the thing learned, and discovered that the knowledge of certain elements gave him a better understanding of the whole, placed these elements in a position of priority. He also discovered that what he learned could be organized in logical sequence and lead in an orderly fashion from what was already known to what was to be discovered. Q.E.D.

The plane geometry text of a century ago fitted into such a philosophy and psychology of education admirably.

Today secondary education is intended for and open to all youth, irrespective of ability, vocational future, or interest. Many more go to college than formerly, but they attend a very different kind of college; college education has been liberalized and is now in the throes of enormous change. Mental discipline is no longer regarded as something which results without regard to the emotional, social and physical development of the individual. In fact, mental discipline is not inherent in subject matter. It is dependent, rather, on the extent to which the individual becomes wholeheartedly identified with the task at hand—the degree with which his whole organism responds sympathetically to the challenge.

In addition, learning is regarded as beginning with a psychological whole—such a part of the individual's environment sufficiently comprehensive to have unitary existence for him at the time when he grapples with it. Learning revolves around this psychological whole in a rather unorderly fashion until sufficient familiarity has been gained with its elements for them to become psychological wholes in turn. No course which begins with elements and proceeds to wholes, therefore, has any right to exist in the modern secondary school.

An examination of geometry textbooks of the last century

reveals little or no change in the organization of the subject. Whether this is due to the fact that the subject matter known as geometry does not permit of a different type of organization, or whether the geometry teacher who becomes the consumer of the textbooks to be placed on the market is lost with a different organization, is not known.

But unless drastic changes can and will be made in the textbook organization to bring the subject in line with modern principles of psychology and education a functional knowledge of geometric principles will not result from the study of geometry. Thus youth had better spend his 120 hours of high-school classroom time and perhaps an equal amount of out-of-class study in a more worthy pursuit.

If geometry cannot be made a creative adventure for youth, the secondary school had better send it the way taken by Greek during the past generation.

MATHEMATICAL MAGIC

By Cecil B. Read
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Ask a person to multiply his age by 1936; find the sum of the figures (digits) in the result; divide this sum by nine and state the remainder. This remainder will be the sum of the digits in the person's age. The answer is not definite, but always within the bounds of guesswork. For the case where the remainder is six, for example, the age might be 15, 24, 33, 42, 51, 60, but there will probably be no trouble in making the distinction. If in doubt, guess the lady at the smaller figure, to avoid complications. If it is desired to repeat the trick, use 1927 as the multiplier instead of 1936.

One may give instructions for the following stunt from outside the room. Common matches are used for counters, although playing cards, poker chips, or similar articles may be used. For simplicity of description, we shall call the two people Smith and Jones. Smith is asked to take any number of matches he pleases, but greater than five. Jones is now requested to take three times as many. Smith now gives five matches to Jones, then Jones is asked to give to Smith three times as many matches as Smith now holds. At this stage, Jones will hold exactly 20 matches. The fact may be revealed, or used as the basis of some other trick. If it is desired to repeat, use four times on both occasions, instead of three times. The result will then be 25 matches in Jones' hands. If the multiplier three is used, with Smith giving Jones four matches, Jones will finish with twelve matches. Similar combinations allow almost endless repetition of the trick without detection.

One could go on indefinitely with such stunts, the illustrations given will doubtless suggest others. No mention has been made of the type of stunt which involves sets of cards prepared in advance, by means of which various numbers are apparently made known by magic. Such sets are described in various books on the subject of mathematical recreations.

TODAY—YESTERDAY—AND TOMORROW IN NATURE STUDY

By Paul Bartsch

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Youth, impetuous Youth, is ever in the forefront of the surging masses, stressing the thought of the immediate moment, which for the instant seems paramount, but which tomorrow may be proved an idle dream. Youth, impetuous Youth, cares little for the basic principles, the foundation stones of all science, gleaned, winnowed and freed from the chaff through the ages. In the educational field this impetuosity of Youth has in recent years been multiplied in direct proportion to the increase in enrollment in our secondary schools and those of higher endeavors.

As one of the older group, intimately associated for half a century with scientific research and educational endeavors in the groups referred to above, and observant of the changes time has wrought, I may take the liberty to express without presumption the statements here offered.

The application of science to our arts has resulted in the mechanization of all of our endeavors, even the educational field. The inventions of new appliances for human comfort and usually well-being, has advanced and is advancing at an almost unbelievable rate. In the higher educational field it has reached the stage where the designation "Trade School" would more aptly define their present status than "University"; for with but few exceptions the matriculants today are seeking a training whose possession they hope to be able to market for a helpful return. The desire to be a member of a broadly cultured group seems today almost nonexistent. The main aim of education today appears not to be the joy which knowledge as such bestows, but its earning capacity in dollars and cents.

I fear Minerva has been dethroned and replaced by a new deity, let's call him MECHANUS, who hand in hand with Mammon stalks our halls of learning.

There are many angles to the problems that constitute Nature Study. There are equally numerous narrowly trained specialists in this field, each an enthusiastic proponent of some specific approach, and absolutely positive that his viewpoint is the only panacea worthy of consideration. It is therefore not

at all surprising that discord instead of harmony rules our ranks.

The FAD of today is the search for the unseen—the un-known—the ultimate, conjured and envisioned in the dreaming and scheming of the speculative mind. We blindly pass by the beauty into which nature has combined these ultimate par-ticles into visible forms that meet our needs, be they actual or spiritual. We are not content with playing with our toys as we see them, but we want to "see the wheels go round," and know their actuating power. Therefore: microscopes—microtomes—micrometers—ovens and baths, not to forget test tubes, stain-ing dishes and dyes form, just as early as possible, the equip-ment used in our leading high schools, colleges and universities in their endeavors to get acquainted with nature.

It is sad when one contemplates that a little while ago chromosomes constituted the goal of these researchers but then came the chromomere with its interpretation to be followed by the mysterious gene, which in turn promises well to yield to the chemical field of compound, atom, ion and by wedding with physics to electrons, positrons, and then what? Probably the endeavor of combining these, a la *Svastri*, to create new things.

There is an old saying that all things move in cycles, or swing like a pendulum from one extreme to another in endless repetition. May we, who still love nature's visible forms, see the day when nature study, in the biological sense will return to a recognition of and acquaintance with the things we see about us.

One of my favorite pastimes has for many years been the taking of visiting professors of biology, zoology, botany, as well as just nature study teachers, on a walk about the na-tion's Capital both indoors and out, and I am forced to say that most of them knew very little about out-of-door natural his-tory. Most of them had a very limited approach to Nature when unaided by microscope and stains.

I would like to see a survey made by the U. S. Bureau of Education to determine how many of the biological science teachers in this country could at sight name 50 or 100 of our native birds or plants, or 20 mammals, fish or reptiles and batrachians, insects or mollusks at home in their community. I fear that "F" would be the predominant rating and this in spite of the splendid work done by Dr. Palmer and kindred en-thusiastic workers in our field.

In my high school days such studies were required subjects in zoology and botany, and for the sake of my grandchildren I hope that the pendulum's swing may return to those joy-bringing endeavors.

The most impressive feature to me at the World's Fair in Chicago was a group of three figures in front of the Science building, facing the main entrance, past which the unseeing multitude, untrained in observing, milled en mass. This group consisted of, let's call them Adam and Eve, and behind these a mechanical man made up of a monkey wrench head and odd and end mechanical parts for the rest of his joints, let's call him MECHANUS. This God held Adam's left hand in his right while his left rested upon Eve's right shoulder. All three figures were bent forward in an eager pose. Adam's right hand was held over his brow, while both of Eve's hands shielded her gaze. Three powerful figures rendered tense by the vision they seemed to behold through a rift of the haze of the unknown—the future—into which MECHANUS was gently forcing them.

Let us hope that the glimpse of this promised land meant even greater happiness than has come to the members of this most favored nation of ours in the past. If that is to be, it seems to me that it can only be achieved through a training that will enable our citizens to enjoy their leisure hours to the fullest extent. Idle leisure breeds discontent and unhappiness. I know of no endeavor that will contribute more real joy than a knowledge of and a love for the out-of-door study of nature.

Looking back over my three score and five years and taking inventory to determine the things that have given me the greatest pleasures, I unhesitatingly say my contact with nature and with this I do not mean the specimens preserved in the collection that I have viewed—No, I mean the living things in their vital environment. The joys of the mountain crags and the life-giving cloud caps that enshroud them, their forests and contained faunas and floras; the plains, the lakes, the streams and sea even in its greatest profoundness, have yielded treasures, not of gold or gems, but a partial understanding of my own little role in this symphony as a whole. And it was nature study, that powerful factor which opens eye and ear, that has made all the experiences that have come to me possible.

Those high school days, bless them, that taught me to know and love for life the first 50 bird friends and plants. Those days came back to me so vividly when climbing out of the steaming

valleys of the low coastal plain to the crater's rim of Bagio in Luzon, Philippine Islands, where we exchanged tree ferns and palms for sighing pines. Though years have passed, I still feel the tightening grip at the roots of my hair and the throb of the heart as I listen to the loved song of the pines measured by the notes of the quanking nuthatch. It was like going home to my northern habitat among my friends of old.

So let me plead for those who would know but cannot for want of suitable aids that we follow the lead of certain European countries and like them produce inexpensive, well illustrated, little manuals for the various zoogeographic subdivisions dealing with the mammals, birds, reptiles, batrachians, fishes, mollusks, butterflies, dragon flies and other orders of insects, as well as spiders, myriapods, crustaceans, etc., etc., and others covering an equivalent field in botany. Such little manuals prepared in attractive non-technical form, easily understood by the masses, would be, I believe, the greatest stimulus to reawaken the slumbering interest in the things that constitute our daily surroundings.

I wish the American Nature Study Society would take this under serious advisement and appoint a committee (I would be pleased to serve on it) to give consideration to this project which I believe will do more than any other endeavor to swing biological efforts away from the present day soporific histophysiological pursuits now so widely employed and of future use to only about two percent of the students subscribing to this work. I believe that such a trend would in time again give us teachers able to recognize and understand organisms in their complete form not merely their epithelia, connective, muscular and neural tissues or sclerenchymas, parenchymas, etc., etc., or cross sections of this, that and something else. Information that all but an exceedingly small fraction of their students would ever see again after they left the halls of learning.

I think that the kind of training which I suggest will yield greater dividends of happiness. Contrast the above collection of tissue names, for such they will surely be in a little while, with the pleasures that come to me each day as I watch my boarders take their meal at the feeding shelf in my dining room window, while I enjoy my breakfast. Here, just now, come the garish cardinal and his modest mate and my blue jay pair, both showing preference for the sunflower seeds. A host of starling and English sparrows, but also juncos and at times a song

sparrow. But I also enjoy a pair of mockingbirds feeding on raisins, peanut hearts and suet, and a downey and a pair of nuthatches, the latter, Oh, so busy all day long carrying sunflower seeds to my oaks where they are tucked away in crevices of the bark to be pilfered by my squirrels and other of the feathered folk. Now and then each fall and spring purple finches stay with me for a while, while during the summer the wood thrushes, catbirds and robins claim their share to which more than 30 visitors have subscribed.

Were I to discuss the migrant visitors that come to my little fountains or hillside bath, their listing would take more time than is allotted to me. Add to this the delight that my Robins and catbirds give me when they return to my feeding shelf after a winter's sojourn in the southland, announcing their arrival with a tut or wey and demanding their raisins, knowing that they have always been served here. Their confidence, familiarity and trust, especially when a little later they introduce their fledglings to me, brings greater joy than movies or theatres have to offer. Add also to this the changing panorama of my plant friends that range from hardy winter green ferns to the first hepatica awakening in spring, through summer blooms to the last asters of fall. These are all my friends who, excepting an occasional tragedy, bring more return to me in happiness than any other returns that I may have.

All this I owe to nature study and that early training which brought a sympathetic understanding of my fellow creatures to me and this should be the heritage of all—let's make it so.

REPLACEMENTS AT POLAR STATIONS

Three hundred and fifty-six replacements for men stationed inside the Soviet Union's extensive Arctic territories are on their way to take up posts along Russia's 6,000-mile Arctic coastline and on islands in the Arctic Sea, Tass, Soviet telegraphic agency, reports.

New wintering parties for several stations in the East, along the Siberian coast, have already reached their lonely observation camp sites. Fifty-nine stations for scientific observations, including the drifting "North Pole" camp, will be in operation during the coming winter. Many of the replacements are recent graduates of courses in exploring given by the Administration of the Northern Sea Route.

At the same time Tass has reported the exhibition at the Paris International Exposition of a model of the tent used by the four North Pole observers.

SOME METHODS FOR THE IMPROVEMENT OF INSTRUCTION IN PHYSICS*

By James P. Davis

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During the period of the rapid growth of the high-school population, the enrollment in physics classes has not been keeping pace with the other high-school sciences. This may be due to several causes—the appeal of some of the newer sciences, the subject matter of the course itself, the reluctance on the part of physics teachers to try out new methods of instruction, and to such poor instruction that the student does not master the material presented.

For the past few years physics teachers have been looking for a method or device to create more interest in the subject, and we have heard papers on the relative merits of the demonstration as opposed to the individual laboratory instruction, papers describing the project method, and so forth, which would perhaps give one the idea that our problems could be solved by the adoption of one general method of instruction. We read about stimulating interest with some general project, such as building a telescope, but very little has been said about teaching the fundamental laws of physics.

I believe that there is no difficulty in interesting students in physics if they can be taught to understand it. No amount of artificial stimulation in the way of projects, or no one method of presenting the subject, can take the place of a thorough understanding of the subject. There is more than enough material of vital interest to the average boy and girl in a usual physics class, but students who do not understand will not be interested and therefore will discourage new students from enrolling in the course.

Our lack of enrollment in physics has come about because students believed the subject too difficult for them. They have taken other high school sciences . . . and why?—largely because they were easier. They could master the material of the other subjects. Many physics teachers, in order to hold any students, have so lowered the standards of the course and popularized it that you would hardly recognize it as a physics course. I do

not believe that the material is too difficult for the high school student, but that his lack of mastery is the result of physics teachers as a group not recognizing certain fundamental difficulties in instruction. Thorough understanding is the first essential in stimulating real and lasting interest.

It is my purpose to discuss a few possible methods and techniques which may be used to improve instruction in the fundamental concepts of physics. I shall place my remarks in three main divisions: (1) Teaching for understanding; (2) Teaching to develop thinking; (3) The development of appreciation. I will be concerned with the mental behavior of the pupil in the light of these three goals of teaching.

TEACHING FOR UNDERSTANDING

In teaching the student to understand, it is first necessary to teach the meanings of symbols. The biggest difficulty in the students' learning is that they have not learned the full meanings of the symbols that they use. Reading, then, is the first unsolved problem of physics instruction. Reading is largely interpretation and students must learn to read the physics book. Reading should be taught early in the course, as a preventive, rather than later, as a cure. Reading difficulties can be analyzed and methods devised to deal with these difficulties. In physics, reading difficulties fall into six major classifications:

(1) Students do not understand the relationship of the units of measurement. Physics teachers too often assume that these relationships are known and do not spend enough time in initial teaching and drill for the student to master them. Continual review throughout the year is necessary.

(2) Students do not understand the scientific terms used. Often students can give a memorized definition of a term with no conception of its meaning. We can not expect the pupils to know the meaning of new scientific terms until they have had the background and explanation necessary for their understanding. Terms should be thoroughly defined in the light of the context of the course. Lists of synonyms can well be used in this connection.

(3) Students can not understand mathematical terminology. Teachers should not take for granted that students know mathematical terms but should arrange teaching situations that will teach the terminology, not as abstract words but as illustrating a given point.

(4) Students can not read formulae with understanding. Regardless of how much mathematics a student has had, he will have difficulty with symbols when used in new settings. We will save time and give a better understanding of the subject if we stop and carefully explain the formulae as we come to them. Students should be taught to see the mathematical relationships and be taught to supply word-meanings in reading formulae.

(5) Students are unable to transform statements into visual figures. As a visual aid to reading, students should be taught and required to draw figures to illustrate what they are reading.

(6) Students frequently misinterpret scientific statements. Misinterpretation is usually a result of not being able to understand the meanings of the words used. A careful explanation of the meanings of almost all words, even to words that you would expect all students to understand, should be made by the teacher. If your classes are the same as mine have been, you will receive some surprising answers to questions asking the definitions of even the commonest of words.

Students vary greatly in their reading ability and in their comprehension of the material of the physics course. As individual difficulties cannot be solved by group procedure, the individual oral test can well be used as a device for working with the separate students. Here the student sits down with the instructor and by means of question and answer the instructor determines the progress of the student and helps the student to solve his individual problems. Lack of understanding can be analyzed and immediate provision for its correction can be made. Various questions will determine if the student knows the meanings of words in their context. Often some small difficulty is blocking the student's ability to go ahead with his work in an understanding manner. The written test will only show that he doesn't understand, while the oral test shows *why* he does not understand. If we can determine why a student does not understand we can generally teach him to understand.

I know that most of you are now thinking that this sounds fine for small classes, but that with your large classes it would be impossible due to lack of time. I started using the oral test with classes of five to eight but I am now using it with classes from twenty-four to thirty students with some modifications. The modifications are necessary with a large class for several reasons: (1) There is not enough time in the average period to

give an adequate individual oral test to every student; (2) If the students become scattered, as they will, in their progress, the instructor becomes a bookkeeper and he can not hold any class discussions; (3) Some provision in the way of additional work must be made for the student who learns quickly.

My procedure is somewhat like this: Each unit is first taught in a shorter time than would ordinarily be given to it, and, except in the first unit, a written objective test is given. If the student correctly answers four-fifths of the possible number of points he is excused from taking the individual oral test. He is then given an individual additional topic covering the work of the completed unit. The tests of the other students are analyzed and, in the light of the mistakes made the unit is re-taught, and at its completion each student receives his individual oral test. A given student may have to return several times for his test, and sometimes for an especially low I.Q. student I will have him learn only the bare essentials. Under this plan each student masters the amount of material according to his ability. Rapid students do additional problems, projects, experiments, reading, etc., while even the slowest student masters the essentials.

At the completion of the first unit I give every student the individual test so that I may gain a knowledge of the ability and instructional problems of each student. The program, then, is one of careful teaching for understanding, testing, analysis of tests, re-teaching, and re-testing by means of an oral test. This plan can be followed with classes up to thirty students in single-period periods. This procedure keeps the class together, keeps the bright students working up to capacity, provides additional instruction for the slowest students and has proved to be very helpful to me.

TEACHING TO DEVELOP THINKING

Most teachers believe that one of the important goals of physics instruction is the development of scientific thinking. They have held up the idea of development of thinking as one of the reasons for students enrolling in the physics course and yet Downing and others have shown that scientific thinking is not developed in the usual science course.

Pupils do not think because they are exposed to science but must be taught the technique of thinking. Several suggestions for thinking in problem solving may be given.

First, the pupil must be taught the meaning of the problem.

This will include the accurate reading of the problem (often by the teacher), the meaning and use of the symbols and the relationships of the parts of the problem. Thinking is the discovery of new true relationships. The problem, then, is to make all relationships visible.

Second, the problem must be in the pupil's world, not the old type "brain teaser" which has no place in the life of the student.

Third, it must be a real problem, a felt difficulty, and its solution must produce some satisfaction.

Fourth, students should be taught to distinguish what is significant between known and unknown. The teacher can demonstrate problem solving and then have the pupils follow the procedure, determining what is significant.

Dewey points out in his book *How We Think* the five stages in a simple act of thought. As these are practically the same stages through which one goes in the solution of a laboratory problem, most teachers agree that laboratory work will inculcate right methods of thinking. But many pupils who have been exposed to the laboratory grow up into non-thinkers as in the past.

One reason why laboratory work has not achieved more success is that the problems were lost in a maze of printed directions which concerned the making of certain definite measurements. Because the relation of the data obtained to the larger problem was not given, all incentive was lost in such work and the only value obtained was one of technique. The laboratory manuals ask too many questions on detail and do not cause the student to relate the data to the problem. The laboratory, then, is often not a place for solving problems, and the pupil does not become habituated in problem solving.

The laboratory can be, however, the best place to teach scientific thinking through problem solving. But scientific thinking has to be developed like any other skill, and the desired outcome will never be achieved by blindly following a set of printed directions.

Dewey states that a problem is a "felt difficulty" and that students must experience it in their daily life. Most problems of physics are not "felt difficulties" until presented as such by the teacher, therefore most problems have to be developed by means of skilfully directed developmental teaching.

After setting up the problem the facts that relate to the solution of the problem must be obtained. Here the teacher must

constantly keep the goal before the pupils. "Why are you doing this?" and "What is the value of this or that step in the problem?" are desirable questions that must be asked continually. The teacher must aid the pupils in becoming aware of the generalized values in the experiment and especially in the step which re'ates to the gathering of facts. The facts must be usable to the student in the light of the major problem.

After obtaining the facts needed, the next step is the reasoning process in which the facts are used as premises from which a logical conclusion can be drawn. Practice in logical thinking must be given if this kind of thinking is to become habitual.

After our problem has been found and solved to our satisfaction, then the conclusion must be validated. This constant testing of results should develop in the student the habit of open-mindedness which is characteristic of the scientist.

In order to avoid the failure that comes through placing emphasis on the gathering of facts, I have, in my own classes, proceeded without any manual somewhat as follows:

First the students, at the suggestion of the instructor, set up a problem and determine the desired objectives; next a class discussion takes place as to possible methods of procedure and a best method is agreed upon; the student then performs the experiment, keeping in mind the objectives and methods of procedure. If there are several different methods, separate groups will perform the experiment in different ways. After completing the experiment the students report their results and a discussion takes place as to which results are correct and why. In this discussion possible sources of error are determined.

I believe this plan tends to develop a scientific procedure and good habits of thinking. The students learn to be accurate in their observations, to know the value of the observations in relation to the major problem, to report them accurately to the rest of the class, to think scientifically and come to correct conclusions, to be open-minded as to the outcome of the experiment, to suspend judgment until all of the observations have been reported, and to criticize one another's work and often their own.

Since this procedure will take more time than using a laboratory manual, fewer experiments will be completed. As the year progresses, however, the students will work faster, ask fewer questions, learn to adjust themselves to difficulties in performing experiments, so the time taken in developing objectives,

procedures and results is not entirely wasted from the point of view of the number of experiments completed. In this plan the laboratory is a place where pupil and teacher can work together and think together.

This method suggested will only be as successful as the teacher is willing and able to sacrifice certain content of the course in order to build scientific thinking. The teacher is the important factor, and only as teachers are trained both in science and scientific method can the goal be realized. Scientific thinking can not be acquired by the students without definite thought and planning by the teacher.

TEACHING FOR APPRECIATION

There is very little literature on lessons in appreciation and there are no references in the field of psychology. The major handicap to the development of appreciation in our schools is found in the limited view of appreciation. Appreciation is thought by many to be limited to the fine arts, and limited to an emotional experience. Most of the teaching has been directed to having pupils like something.

I believe real appreciation is essentially an intellectual rather than an emotional experience. If it is an intellectual experience, then appreciation begins with understanding, and without understanding there can be no appreciation. The idea that we will teach appreciation of physics to our students that do not understand the material of the course is all wrong. I have heard teachers say that some of their students had so little ability that they could not teach them the basic principles so they were going to teach them appreciation. I do not believe it can be done.

Interest is also essential to appreciation, but here again I believe that teachers often do not understand themselves what is involved in interest. It is not the idea of entertaining the students, but is rather a reciprocal relationship. It is not the idea of making the work easy and pleasant, for learning can not be made entirely easy and pleasurable. Learning physics is a difficult thing and the idea of making it easy is all wrong for it presents the attitude that all life is easy. Interest is based on understanding and a student does not mind hard work if he sees that he is mastering a given unit.

Appreciation then depends on valuation, based on understanding, and also on evaluation, the judgment of values. A

child, therefore, can not appreciate until he has had enough experience.

My plea is to stop saying we are teaching appreciation until we have taught basic principles. Let us teach the pupil to understand the fundamental concepts of physics, to think scientifically, and then by teaching evaluation we can have the student learn to appreciate.

SPONTANEOUS COMBUSTION

By Saylor C. Cubbage

Woodrow Wilson High School, Washington, D. C.

Fires often occur which are attributed, rightly or wrongly, to spontaneous combustion. I observed a small fire a short time ago that could hardly be attributed to any other cause. A boy was applying linseed oil with a cloth to a small piece of furniture he was finishing in the woodworking department of the high school. At twelve o'clock he laid aside his work and pushed his apron into a wooden locker. Carelessly he dropped the oily cloth into the locker along with the apron. He closed the locker for the day and went to lunch and finally afternoon classes. By three o'clock a thin column of smoke was issuing upward from a crack at the top of the locker from the burning of the apron and cloth. Even though the locker was fairly tightly closed enough fire had developed to make the interior intensely hot. This result came about in the short space of three hours by the heat released in the oxidation of the linseed oil. Since there was no way for the heat to be dissipated it collected until the kindling point of the material was reached and fire resulted. This incident illustrates the relation between oxidation and combustion. It is a matter of degree. Ordinary oxidation takes place at a slower rate than does combustion. There were no matches present which could have started this fire.

The science courses in our schools can do well to teach the pupil that fires develop spontaneously and the ways in which such fires can develop. There are many people living in our civilization today who believe that there is no such thing as spontaneous combustion. They scoff at the idea. Frequently one hears of fires the causes of which are hard to ascertain. The mischief maker, spontaneous combustion, is often at fault. Every year many homes are ignited from oily cloths being dropped in closets to get them out of the way. Fires start in piles of leaves which have collected in ravines in the forest; barns which have been packed with damp green hay burn to the ground to the dismay of the owners. Haystacks sometimes burn in the field. In many cases the cause is spontaneous combustion. Skeptical people attribute such fires to lightning or to persons who are too careless with matches or cigarettes. All of these agencies are capable of starting fires but it is a fact that conflagrations sometimes begin with oxidizable materials being placed in closed places from which the heat developed in oxidation cannot be disseminated easily. As the heat collects the temperature finally reaches the kindling point of the material and the fire starts. Such materials should not be piled up but should be scattered so as to permit free circulation of the air in order that the heat may be carried away as rapidly as released until oxidation is complete.

MICRO-PROJECTION—HOME-MADE AT A LOW COST

By L. F. Pinkus
Sigel School, St. Louis, Missouri

Since its enthusiastic reception several years ago, micro-projection has been accepted as an important visual teaching aid. However, the prohibitive cost of commercial equipment has
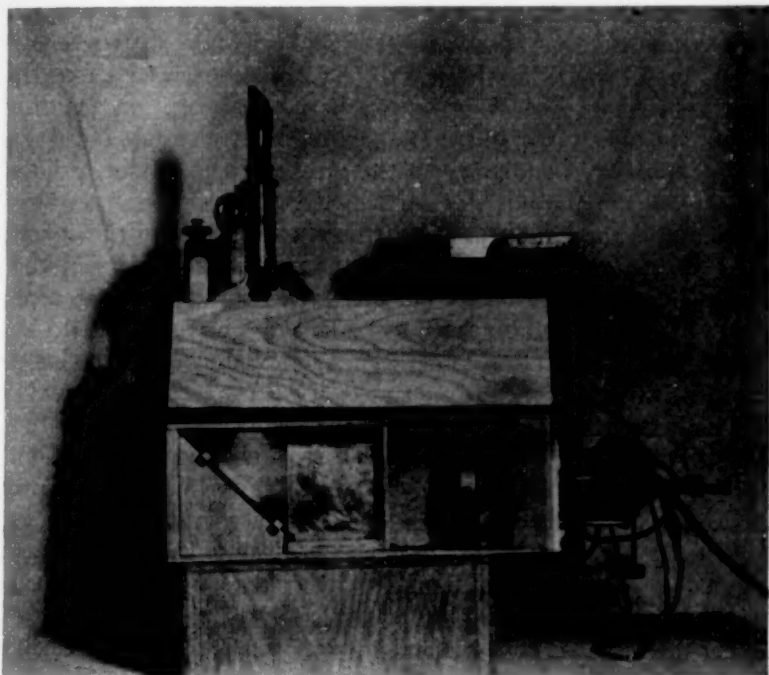
made any widespread use of it practically impossible in the secondary schools. After witnessing the excellent demonstration of Dr. Roemer of Chicago, I felt that I must find some way of bringing micro-projection into my classroom. It offers such dramatic demonstration of many of the mysteries of the minute cell world, as when one sees the protoplasm movement in anarchis, the budding of the yeast cells, the cell division of one-cell plants, the structure and movements of paramecium, as well as mounted specimens.

My problem was to construct a micro-projector on a very modest budget. As you see the result the total cost for the ap-

paratus was approximately fifteen dollars. Time for planning was probably considerably longer than for the making, with several trips to second hand shops until I finally procured the parts. The essentials are a ten ampere rheostat, arc lamp, condenser, cooling cell, mirror, plywood box, and a microscope with reversing prism. The box which assembles the material is four by five inches and sixteen inches long. One end was cut out to fit the arc lamp and faced with asbestos and the arc lamp was set in to adjust laterally. The four inch condenser was moveable to accommodate the point of focus. A space of two inches separated the condenser and water cell. The cell was constructed of monel metal with glass front and back and contained a ten per cent solution of potassium alum for heat absorption. At the end of the light box a mirror was mounted at an angle of forty-five degrees. Perpendicular to the center of the mirror, a hole was cut in the top board, over which the microscope was centered. Thus the light travelled from the arc lamp to the specimen, through the microscope and the reversing prism sent the focussed image onto the screen. Any type of student microscope may be used, preferably with a condenser. The room should be darkened for projection and the image should be thrown on a smooth white screen.

There are many problems that can be effectively surmounted with a micro-projector. The difficulties of the secondary school students in using the microscope are well-known to us who are their teachers. And there is the question of cost of microscopes for each individual. With the micro-projector, the teacher can focus living material or mounted specimen and project it in size large enough for easy observation. In using the micro-projector, the teacher controls the microscopic field and can easily adjust it for his purposes.

I have found two helpful ways of including the student in the demonstration, in order that the micro-projector should fulfill its constructive educational purpose as well as to test its teaching effectiveness. After having viewed the specimen for a sufficient span of time, the lights in the room are turned on and the pupils are asked to draw the specimen from memory in their copybooks. The more difficult specimens are presented in mimeographed form and after the micro-projection the students are asked to re-identify them. Follow-up tests of the demonstrations have proven that the students formed and retained a proper concept of the microscopic world.

IN IMPROVED OVERFLOW CAN

By William A. Porter

School District No. 40, Chisholm, Minnesota

In performing specific weight experiments by the displacement method and using an overflow can, errors due to surface tension prevent any great degree of accuracy. In attempting to overcome this difficulty, William Tancig, one of my students made use of the "intermittent siphon" principle and developed the device illustrated below. This overflow can starts as soon as
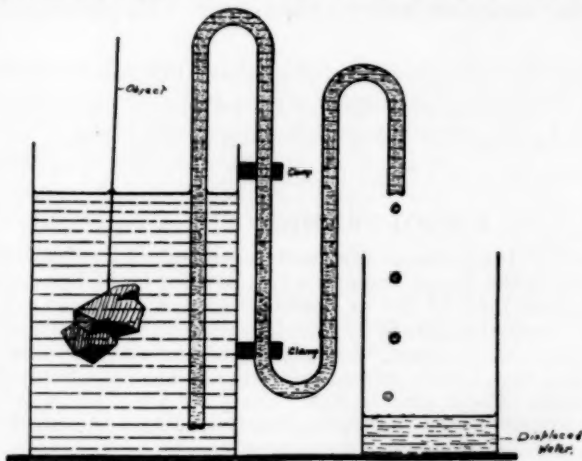
the object enters the water and stops when the proper volume has been displaced. A series of tests show an accuracy entirely adequate for secondary school purposes. Since the device can be easily made in any science laboratory, others may wish to construct it for their own use.

The container may be any can 3 to 4 inches in diameter and 5 to 6 inches deep. The tubing may be of glass although we found copper more desirable as it will not break and can be fastened to the can more securely. For best results, the inside diameter of the tubing should be $\frac{1}{4}$ inch. The tube must be securely fastened to the can as a small movement either up or down will result in a considerable error.

DIRECTIONS FOR OPERATING THE IMPROVED OVERFLOW CAN

1. Weigh the object whose volume is to be measured and record.

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2. Fill the can full of *cold* water.

3. Start the siphon operating, by sucking on the end of the tube, collecting the excess water in a beaker. The overflow can is now ready to operate.

4. The water that will be displaced, may be collected in a small accurate graduate and the volume found directly, or collected in a vessel and weighed. The object whose volume is to be measured is gently lowered into the can and the displaced water collected and measured.

5. To reset the can for a second determination, fill with water and at the same time remove the object. This prevents "loss of siphon."

6. Since the volume of water displaced equals the volume of the object, the specific weight of the substance equals its weight in air, divided by the volume of water it displaced.

A ROOT-FORMING CHEMICAL

"Hormodin" is a hormone-like plant growth substance developed in the laboratories of the Boyce Thompson Institute for Plant Research, Inc.

The purified form of the first isolated growth substance was named "auxin." Stimulating growth by cell-elongation, and the capacity of moving downward in the plant, were attributed to "auxin." Further study showed that two closely related substances were responsible for these growth effects. These were named "Auxin A" and "Auxin B." Later a third and entirely different growth-producing substance, named "Hetero-auxin," was found to produce the same effects.

The discovery that several synthetic crystalline substances caused growth responses in plants served as the basis for the preliminary work in this field. These synthetically prepared growth substances are now furnished under the name "Hormodin."

Hormodin makes it possible to propagate practically all varieties of plants from cuttings. The growth substances are not specific for certain varieties or groups of plants. To treat cuttings with Hormodin, merely place the basal ends of the cuttings in the water solution for a designated period of 4 to 48 hours. The cuttings are then removed from this solution and planted in a propagating bench. Cuttings so treated root quicker and have more roots per cutting.

Hormodin is manufactured by Merck under license from the Boyce Thompson Institute. The price is $1.00 for 5 cc., $2.00 for 15 cc., and $7.00 for 60 cc.

AURORAS

Brighter auroras were predicted for the next two years by Dr. Harlan T. Stetson, Massachusetts Institute of Technology astronomer.

A gradual increase in the number of sunspots from the minimum reached in 1934 has led Dr. Stetson, formerly director of the Perkins Observatory, to make his prediction. An increase in the number of auroras usually follows an increase in solar activity by two years, he points out.

THE DIFFICULTY OF THE CONCRETE

By J. B. Shouse

Marshall College, Huntington, West Virginia

Of arithmetic Margaret Drummond has said that it "differs from most subjects in that the hardest step of all has to be taken at the very beginning."[1] This she has said signifying the abstract character of number concepts. "At the very beginning the child has to leave the world of concrete fascinating realities and concentrate on an abstraction, on a creation of the human intellect."

Hers is by no means an isolated instance of such judgment. "In general, we find that pupils experience great difficulty in the mastery of the complex number system which modern civilization provides for them. . . Perhaps the most impressive way of stating the situation is to point out that the number system is a highly abstract system."[2] "At the one extreme, then, is the highly perfected number system, a system sanctioned by society and requiring of the learner control of the most abstract mental processes. At the other extreme is the child with his undeveloped powers and his immature capacities."[3]

Miss Drummond may be quite justified in her statement. But she proceeds to weaken her position. She does this in two comments. (1) The "dropping of the name of what we are adding is a comparatively easy step." (2) "we often leave it uncertain what kind of things we mean for results come out the same, whether we refer to oranges or sailors or soldiers. Children have no difficulty in realizing this." Now in the first of these admissions it is implied that we may mentally carry the denomination of our concrete objects, not using it overtly. One naturally wishes to ask whether this is not a step in thinking abstract number. Abstraction in number situations is nothing other than isolating the number from particular relations to objects. If Miss Drummond is correct in saying that it is "a comparatively easy step," it would appear that greater difficulty has been ascribed to the transition from the concrete to the abstract than is entirely justified.

[1] *The Psychology and Teaching of Number*, page 10. World Book Co., 1922.

[2] Judd, C. H., *Psychological Analysis of the Fundamentals of Arithmetic*, page 13. The University of Chicago, 1927.

[3] Brownell, W. A., *The Development of Children's Number Ideas in the Primary Grades*, pages 193–194. The University of Chicago, 1928.

In the second concession, there is reference to a certain generalization, namely, that "results come out the same" numerically for all manner of concrete situations actually employing the same number of objects. This generalization is asserted to offer little difficulty; yet that it signalizes a step toward freedom of thinking about numbers as such, number in the abstract, seems quite evident.

Arithmetic is difficult. Number is abstract. Granted. Does it follow that all of the difficulties found in number work are due to the abstractness of number? It would seem good policy to ask to what extent the field of concrete number also reveals difficulties. We may thereby discover that the abstract character of number has been made the bearer of undue blame for the difficulties encountered in arithmetic.

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Both Howell and Brownell have experimented with dots as objects for children to count, the process of counting being assumed as a basic number activity. Dots may be arranged without pattern or in a great variety of patterns. Howell[4] concentrated on one special pattern wherein dots are arranged in groups of four, with partial fours as occasion may demand, thus—:: :: :. These groups of dots were exposed to children by means of flash cards, time of exposure being under control. The object to discover what groups of dots, so presented, are easiest of visual apprehension as to number of dots, this apprehension not being identical with counting, but yet involving the use of numbers approximately on the level of ability to count.

In the work already quoted, Brownell has reported somewhat similar experiments designed to check Howell's findings. But Brownell did not confine his work to the use of a single type of arrangement of dots. Using five different patterns Brownell found that percentages of error in apprehension of number of dots shown vary with the pattern.[5] In other words, although the character of the concrete objects does not vary in these experiments, the patterns do vary, and variation in pattern makes a different concrete situation, sufficiently different to affect visual apprehension of the number of dots presented. To apprehend seven dots, for example, arranged one way is one thing; to apprehend seven dots arranged according

[4] Howell, H. B., *A Foundational Study in the Pedagogy of Arithmetic*, part II. The Macmillan Co. 1914.

[5] As in 3, page 23.

to a different pattern is quite another matter. The difficulty of the number operation is affected by a change in the concrete elements of the situation. Certainly the variation in difficulty has nothing to do with the abstractness of number, in this case. Brownell recognizes this, speaking of the "difficulties encountered by children in acquiring mature methods of dealing with concrete numbers."[6]

* * *

Judd chose to deal with situations requiring true counting, with the "objects" of counting presented seriatim. Conducting experiments with adults, Judd used controlled series of sounds and of flashes of light.[7] That intervals between events of any series were equal favored the subjects of the experiment; supposedly no subject was caught off guard because not in a state of readiness or expectancy of the event as he might have been had no simple rhythm of presentation been maintained, although, to be sure, time intervals were different in different series. On the other hand, the regular succession of events in any series means that the subject never did experience the group of "objects" as a whole. Counting had to keep up with the procession of events without opportunity for correction by re-survey of the group.

In what appear to be simple exercises in counting, adult subjects made errors. These errors surely cannot be laid to an inability to count. The exercises required maintenance of one-to-one correspondence between number series and event series. The unusual nature of the counting situation may be held at least partly responsible for the errors made. With neither type of stimulus, sound or light flash, could the subjects count with their usual facility and accuracy. And counting sounds in series proved to be different from counting flashes of light.

Confirmatory of such impressions are the results of additional experiments by Judd in which he used unseen taps on on the back of the subject's hand as the objects of counting. This proved to be a more difficult operation than is counting flashes of light which, in turn, is more difficult than is counting sounds. Difficulty apparently varies with the subject's accustomedness to the counting situation. In his discussion of the whole series of experiments Judd (as is Brownell in relation

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[6] Same, page 81.
[7] As in 2, chapter II.

to his own work) is perfectly clear as to the fact that a change in the concrete elements of the number situation affects responses, that "each type of counting is a complex experience, depending for its character on the individual's training and on the method of procedure involved."[8]

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Investigators have reported[9] the results of tests with six-year-old children at the time of first school attendance in a number of Ohio towns and cities. Several different situations were devised by way of finding out how well beginning first grade pupils can count. Results of the investigation are applicable to the present discussion.

Asked to count as far as possible, 1126 of 1290 children counted on first trial without error as far as 11; on second trial, 1150 got that far. The investigators concluded that "certainly 90%" of the children tested could count to 10, when the criterion of counting ability was recitation, in proper order, of number names.

As a check on this measure of counting ability, the children were next asked to count as many as possible of 20 objects provided for the purpose, designating objects in succession while counting. Performances are reported as follows: On first trial 86.7% counted correctly as many as 11 objects; on second trial, 87.2% were accurate to that point. "The evidence . . . does not support the view that children are likely to be much more successful in rote counting without objects than they are in counting objects . . . almost as large a proportion of the children were successful in counting objects as were successful in rote counting. This statement is further supported by the fact that almost exactly the same proportion of children succeeded as far as 10 in both types of counting—namely about 90%." This implies that the children actually understood the significance of number names to the indicated point.

A twist was given to the tests. The children were asked to pick up an indicated number of objects laid before them, an act adding the picking up to the recitation of number names and the keeping of the two series (words and objects) together. Data are given for results on numbers 5, 6, 7, 8, 10. With each

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[8] Same, page 35.
[9] Buckingham, B. R. & MacLatchy, Josephine, "The Number Abilities of Children When They Enter Grade One." In *Twenty-ninth Yearbook, National Society for the Study of Education*, chapter IV, Public School Publishing Co., 1930.

number three trials were given, at intervals. Three correct counts on three trials were made as follows: for 5—64.4%; for 6—56.2%; for 7—53.7%; for 8—48.8%; for 10—50.2%. Corresponding percentage results for at least one correct count in three trials: for 5—85.3; for 6—80.3; for 7—80.7; for 8—78.0; for 10—76.6. Evidently the requirement of picking up the objects while making the count introduced an additional factor in the total situation which made the demand a more difficult one. The situation was certainly not made more abstract by this requirement.

Again the test was changed. The teacher laid down, without pattern, a certain number of objects, asking each pupil, "How many ————————— are there here?" The report does not indicate whether, in this case, pupils were allowed to touch or to point to objects or to count aloud. The requirement merely called for the number of objects displayed. For three correct trials percentages are reported as follows: for 5—62.5; for 6—51.9; for 7—46.4; for 8—45.1; for 10—42.1. For at least a single success in three trials: for 5—81.5; for 6—75.0; for 7—74.3; for 8—72.2; for 10—70.4. These percentages are noticeably, although not greatly, lower than those reported for the preceding test, indicating that the test offered still more difficulty.

In sum, the report of Buckingham & MacLatchy makes it clear that the introduction of even slightly different demands upon the counting ability of the children affected the difficulty of the counting act in the concrete situation so set up. The ability to count abstractly was present; there was objective evidence that the counting could be done in the very simplest of concrete situations; but the act of counting could not be correctly applied to even slightly more complex situations. The difficulty was manifestly related to application of understood numbers to entirely concrete situations. Any change in the concrete particulars of the situation may create a different situation. The different situation calls for a different act of application. This has nothing to do, however, with the abstract character of number.

* * *

We talk a good deal about concrete number. Strictly speaking there is no such thing as concrete number. Number is always abstract. The number idea cannot be anything but abstract. It must be thought into the concrete situation and is not inherent in it. "Number is a device to aid thinking; it is

an aid to the mind. It is a human invention, not a fact of the natural world."[10] What we call concrete number is really applied abstract number.

It seems to be commonly assumed that the process of acquiring number ideas follows the ordinary formula for the development of abstract ideas. We experience a situation containing an element to which attention becomes directed. We find it possible to think of that element more or less independently of concomitant elements. Perhaps we observe the same element in other situations, in combination with other concomitants. But such additional situations are not always necessary; abstraction may be effected on the basis of a single experience. The instant we are able to think of the element by itself we have performed the act essential to abstraction. To be sure, additional experiences help to clarify the abstract idea; experiences in which the concomitant elements are varied help us to establish generalizations about the element we are abstracting from the complex situations. But the really fundamental thing is that we should have detected the element in question as an aspect of the situation that can be considered by itself, and that we should have mentally isolated it and given it this consideration. In this description it is, of course, implied that the element in question is inherent in the total. In such case the abstract idea issues from the act of thinking about concrete situations. The act of abstracting is the act of thinking the element *out of, not into*, the situation.[11]

Now if number is not inherent in the concrete situation, but must be thought into it, then the development of the abstract idea requires a quite different description. The first steps toward number do not involve concrete situations at all. The first act in the direction of number consists in reciting number names as mere rhythms of sound, the number words themselves being so much nonsense material. To these meaningless sounds meaning becomes attached through their employment in relation to concrete situations. The growth of the meanings of number names proceeds as does the growth of meanings of other words—through their use, their application. Buswell & Judd

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[10] As in 2, page 8.

[11] Since writing the paragraph, I have noted the following clear statement: "In the first place, the abstracting type of thinking involves the analysis of things into their constituents, and secondly the drawing out of particular features and qualities or the abstracting of some complete or partial resemblances of qualities to others, with some pragmatic disregard of the residuum of qualities or other features." Kantor, J. R., *Principles of Psychology*, vol. II, page 165. Alfred A. Knopf, 1926.

have provided an excellent analysis and description of this process:[12] "Studies in the psychology of counting have shown that counting is first a motor response to an inner rhythmical series without reference to objects. This early counting experience begins with certain rhythmical movements of various kinds and later is expressed through rhythmical articulation, using number names. Later, counting develops into the mechanical application of number names to external objects, the process developing through practice until the inner series of motorization and the outer series of objects correspond in exact fashion. Still later, this counting becomes more rational in character as the relation of the various numbers is learned. . . "

The approach to the number idea is quite different from the act of abstracting an element from a complex. The usual account of the process of abstraction applies to cases in which the thinker perceives the element in the total and thinks of it by itself. There is this other type of situation to be considered in which the individual does not go through any such process of analysis, but starts with a meaningless performance (not, of course, meaningless in the sense of not offering a satisfying experience). It is contended that the number idea is acquired by this second kind of process, which is not a process of abstracting at all. Number is abstract, but its abstractness does not rest upon the fact that the individual abstracts the number element from among a variety of elements in a complex. The abstractness of number rests upon the fact that number is a mental product, pure and simple. "Number" is not a name for an element in a concrete situation as is redness, which, to be thought of, has to be thought out of the situation in which it is resident.

<p style="text-align:center">*   *   *</p>

This accounts for the ease with which children can ignore denominations of numbers, get along without them, as noted by Miss Drummond. They first use number names without reference to objects. Grant that these number names must be related to objects in order to become meaningful. Nevertheless the early familiarity with number names unrelated to objects makes it relatively easy, once the meanings of the several num-

[12] Buswell, G. T. and Judd, C. H., *Summary of Investigations Relating to Arithmetic*, page 59. The University of Chicago, 1925.

bers have been acquired, to think in terms of number words without reference to objects.

Brownell[13] is insistent upon the greater difficulty of abstract number than of concrete number, and recommends the use (at certain stages) of number pictures (dot patterns) as a means of transition from concrete number situations to abstract number situations. This matter of transition from situation to situation is exactly the point to be considered. Brownell's own experiments indicate that every time a transition had to be made from one dot pattern to another the difficulty of the arithmetical act was affected. Transition is the very nub of the problem. Certainly transition from concrete to abstract—if that is the direction of transition—offers a place of difficulty. So does transition from one concrete application to another also offer difficulty. By no means all of the difficulty of transition attaches to this particular transition—from concrete to abstract —although we often speak as though that were the case. In fact there is abundant evidence that counting, just counting, objectless counting, is an easier process than is the counting of objects of certain sorts.

We display a tendency to ascribe the difficulty of transition from number situation to number situation to the abstractness of number, as if the transition would offer no difficulty if we properly knew abstract number. Of course it is the abstract character of number that permits its application to this situation and to that, that permits it to be thought into a particular situation. But many a person who deals competently with number in the abstract has been brought up short when confronted by some particular opportunity to apply his knowledge of number.

Dr. H. H. Goddard once mentioned to me a grown man, inmate of a training school for mental incompetents. This man, according to the story, took care of a team of horses at the school, employing the team for the hauling of coal from railroad track to institution. One day Dr. Goddard met the man, during the noon hour, and, by way of friendly greeting, asked questions about the day's work. How many loads of coal were hauled this morning? Three. How many will be hauled this afternoon? Two. How many tomorrow morning? Three. How many loads make a full day's work? Five. Of these facts the man was certain. To such questions answers were brought forth without hesitation.

13 As in 3, pages 218 et seq.

But, asked to tell how many three and two together make, the man was unable to say.

Superficially considered it appears that the man could deal with simple concrete numbers, but was unable to make an elementary transition to an abstract consideration of the numbers involved. One may not be entirely convinced of the correctness of such opinion. One wishes to ask questions. Could he have told how many three loads of coal and four loads of coal make, his experience being with three loads and two loads? Was not his difficulty due to the fact that, although by dint of repetition of hard experience he had learned the facts about a particular situation, he simply was not competent to adapt his learning to a slightly altered situation? Was the abstract aspect of the question the real stumbling block?

In the course of the same conversation Dr. Goddard related the tale of a young woman, also mentally undeveloped. Her institutional assignment was to the making of beds, which task she was able to accomplish with notable skill. But, suggested Dr. Goddard, let some one offer to help in the morning making of a bed, and it would at once become apparent that the young woman could not adapt herself to such a change in the situation as having a helper. Only protracted training would bring her to the degree of skill in cooperative bedmaking that she had attained in singlehanded performance. There could be in this case no hint of an abstraction that must be dealt with. The woman, like the man, could not readily adapt developed reactions to a new condition.

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The problem in arithmetic comes to be seen, then, not primarily as the development of the understanding of abstract number through a succession of concrete experiences, but more largely as the development of ability to apply number knowledge to successive concrete situations. Each of these successive situations must be analyzed to the end that one can isolate the elements of the total situation to which number knowledge is applicable. This analysis is the locus of much of the difficulty experienced in arithmetic. Insufficient experience in application of arithmetical facts is indicated. Not less, but more, arithmetic is needed, more training in the use of the arithmetic that we know.

AN EXPERIMENT IN THE TEACHING OF HIGH SCHOOL CHEMISTRY

By J. M. Levelle

John Marshall High School, Cleveland, Ohio

In this modern age of mass education in which pupils are required by law to attend school until they reach a given age; in which the pick and shovel worker is considered as having been a rather foolish person because he didn't finish high school and college thus insuring himself a white collar job with the possibility of becoming pleasantly stoop-shouldered behind an office desk: perhaps there is still room for one person's opinion as to whom we should teach. Theses have been and will be written upon *what* should be taught and *when* it should be taught, so possibly we may well pause to reflect upon the various qualities and potentialities of the individual upon *whom* this thought, preparation and money are being spent.

The writer has spent the past seven years in a large and thoroughly modern, city high school, doing his humble best in introducing his charges to the fundamentals of the science of chemistry. The observations and opinions herein recorded are not the results of long, laborious hours of research into the various psychological and educational treatises which might furnish information upon the subject; but a summation of facts gained through several years of teaching high school sciences. There is no intention of setting up any conclusions drawn as criterions of authority upon this or any kindred subject.

The course in first year chemistry as constructed in this high school consists of three lecture periods and two double periods of laboratory per week. Each period is 45 minutes in length. The course is elective, and has the usual strong competition resulting from so many other courses being required for graduation. It is taught in the senior year, although due to curriculum conflicts we always have a number of eleventh year pupils enrolled. Our equipment is only three and a half years old, has been judiciously used and cared for, and there is ample opportunity for interesting and constructive work by our pupils.

All high school pupils may be classified in several different ways. (a) They work or they loaf, and I class the one who is only fair, who does just enough to "get by" as a loafer. (b) They are smart or they are of lower mentality. (c) They have

initiative, perseverance, "backbone" or they haven't, and so on and so on. Some readers may believe there is a rather close correlation between these various traits. A student who is smart will work; one who works diligently will have initiative, etc. I do not agree with anyone holding such views. I do not hold that no such correlation exists, but rather that it may be overemphasized. Upon reflection of such experience as I have had, I become rather impressed with the heterogeneity of pupil characteristics. Some of the best ones have been of ordinary "IQ" ratings; the smart ones have loafed; rather indifferent pupils have displayed remarkable initiative, having been given the proper incentive.

The sincere desire of this teacher, as with all teachers, is to impart to all these pupils as much fundamental chemistry and laboratory technique as possible, as well as build character, guide vocationally, and the host of other things which a good teacher should and must do. The pupils in a typical class in most any high school subject usually represent all that is thoroughly desired and disgusting to that teacher. They merely indicate chemistry on their schedule and unless the homeroom teacher inquires as to their plans for the future, and advises accordingly, into chemistry they come!

Perhaps I may state my case more clearly by citing illustrations, none of which is unusual or farfetched. (a) A class of pupils was preparing oxygen in the laboratory. The directions given for the experiment started with the list of apparatus and materials needed. One boy got his equipment set up, and placed manganese dioxide, potassium chlorate, sulfur and cotton, in the test tube in which the gas was to be generated. I think the only reason he did not put in his wood splints, magnesium ribbon and some other materials was due to lack of space in the test tube. Needless to say, shortly after heat was applied to the test tube a violent disintegration of said tube occurred, with the result that we never found a very large piece of it. Fortunately the flying glass did not strike one of several pupils working nearby.

(b) Another pupil, supposedly following correctly printed instructions, wished to make chlorine water. Going to the stock room he asked for and received, con. H_2SO_4. This was subsequently poured into a tube containing a few crystals of $KClO_3$, with obvious results. The acid was thrown out of the tube and over the boy's face, fortunately missing his eyes, and his burns

were covered by bandages for some little time afterward. Merely reading directions and using the specified HCl would have prevented all this.

(c) Two boys decided that they would synthesize sulfuric acid using the contact process and Fe_2O_3 as a catalyst. Carrying their regularly scheduled load of laboratory experiments, they spent extra periods during and after school hours; met with a number of reverses, any one of which would have taken the ordinary student "out of the play." And finally they were ready to make their first "run." They were asked to place their equipment on the lecture room demonstration table and show it to the class. This was done, was successful, and I felt that two boys had not only learned some chemistry, but developed still further some traits of character which no doubt in later life would do more for them than the chemical information they had gained.

(d) Two other boys, upon a suggestion from the teacher, set upon the project of constructing a constant temperature oven. Spending much spare time in the laboratory, with such things as glass tubing, mercury, toluene, two wooden lard pails, a six volt transformer, etc., they have it practically completed now, and in a matter of days will, in watching the development of a chick embryo in their oven, experience that feeling of success and satisfaction that comes only with the knowledge that a worth-while job has been well done.

Surely there is no doubt that with some of the students mentioned, the teacher should spend as much laboratory time as possible; with others, a combination of lectures and demonstration would have been best. However, the fact remains: we are sent both kinds. What shall we do about it?

There are a number of possible solutions. On one extreme, schools have discarded the laboratory as an aid in instruction. The pupils hear lectures, endure question and answer periods, watch the teacher run demonstrations, and one of the best sales arguments for high school chemistry has been taken from our subject. Of course this method enables a given teacher to teach more classes and more pupils than could possibly be taught in a lecture, laboratory course. "Drive more cattle," in other words. The almighty dollar creeping in again. Unfortunately the worth of many teachers is measured in terms of statistics and factual knowledge their pupils may give to a supervisor on a comprehensive test covering classroom and textbook information. Some will say that pupils who have been taught by

the lecture-demonstration—no laboratory method—learn as much chemistry (as measured on tests) as those pupils having had laboratory as part of their work. I would answer this in two ways. First, that there are many qualities which we hope and try to instill into our pupils, which cannot be measured by pencil and paper. Secondly, that such a line of reasoning is an argument in favor of our proposed experiment.

The opposite extreme, is of course, that method of teaching chemistry wherein the pupil received two or three lectures or questions and answers periods per week, and two or more double periods of laboratory work. In between these extremes would come the scheme of having three or four lecture or demonstration or question and answer periods per week, with only one double period, or even one single period of laboratory.

The writer is very fortunate in being able to work in one of the most modern high schools in a large city, in one which has been designated as an experimental high school. We are trying many new ideas, methods, teaching techniques and watching, fascinated, for possible results. Particularly is this true in our science department. We are all quite thrilled by the possibility of methods now under experimentation in our school being installed at some later date in other schools of the city. We are also cognizant of the resulting responsibility that is ours.

During the past thirty weeks of school, we have attempted to ascertain several things relating to the subject of high school chemistry.

We wondered just what pupils thought of the laboratory as a part of the course in chemistry. We have answered this question satisfactorily—I should say rather that our pupils have answered it. Previous to October 26th of the present school year, pupils had spent the usual two double periods of laboratory work and called it a week. They had had no real opportunity to use the laboratory at will, and as much as they liked, and just from established custom had become used to 4 periods of laboratory weekly, and that was all.

About the end of the first 6 weeks of school, a general announcement was made in three 12A classes to the effect that from that date forward, the laboratory would be open all but two periods of a 9 period day, any pupil being allowed to use it as often and as much as he wished, with these qualifications: (a) Extra time spent in the laboratory could not be substituted

for regularly scheduled laboratory periods. That is, a pupil could not loaf during his regularly scheduled periods because of the possibility of making up the work during "overtime" periods. The few loafers we had were denied the right to overtime in the laboratory if they were falling behind during their regularly scheduled periods. (b) As much as possible, overtime work in the laboratory was to be spent on experiments and projects other than regularly scheduled work. (c) Pupils who did not work and work at something definite and acceptable to the instructor, were to be denied the right to spend extra time in the laboratory. (d) All extra time spent in the laboratory, was to be recorded on so-called "overtime" slips designed for the purpose. The pupil recorded each extra period on one of these, and after having been signed by the teacher, was filed in the stockroom. No force, or persuasion of any sort was exerted on the pupil by teacher. It was desired that results be as free from this as was at all possible. Pupils were told clearly, that they could come to the laboratory, or stay away. Nothing would be given to or taken away from them in either case.

During the twenty-two weeks this plan has been in operation, over 700 overtime pupil periods have been spent in the laboratory, by 71% of the pupils enrolled in the three classes. I think anyone will agree that such figures, carefully obtained, speak for themselves.

It is our desire to give to that pupil having good mental ability, initiative, etc., all the chemistry he can master. Believing that the poor disinterested pupil who must be continually prodded, should be relegated to a class composed of members of his own type, we wish to teach these pupils as well and thoroughly as we can—but have also decided that more thought and energy should be spent upon the real student, who has scientific possibilities. In other words, we are beginning to wonder whether or no the pendulum has not swung too far toward that extreme in which we try to make possible college students of all our charges, to the everlasting disadvantage of our few high potential pupils who are necessarily forced to work with and at almost the same rate as the student whose mental "ceiling" will be reached when he becomes a taxi driver or a night watchman. Let us give our very best to all of them— that we sincerely wish to do. We are, however, just as earnest in our desire to give it to them in such a manner as will enable all to benefit to a maximum, and allow each to receive all he can

comprehend. The proposed schedule herein submitted may answer our problem and it may not. It looks well on paper but it hasn't stood the acid test of trial. We hope it will live up to our expectations and will enjoy watching it succeed or fail. Every pupil enrolled in high school chemistry deserves some laboratory experience; if he doesn't receive it we not only destroy much of the glamour of our subject, but what is more important, we strip away all possibility of pupils experiencing the basic essential in any science—experimentation. And in the withering sunlight of critical examination, we present this experiment.

A Possible Chemistry Schedule

Under a system whereby better pupils are given a maximum of laboratory work, and poorer pupils are taught by a combination lecture-demonstration method.

First Semester

All pupils are taught in the usual manner. Three lecture periods per week, and two laboratory periods of two periods each. In this way, all pupils receive opportunity for becoming acquainted with laboratory technique and the handling of apparatus, and the invaluable possibility of thinking for themselves.

Second Semester

All pupils will be divided into two sections, those who for any reason have done poor work (F or lower) during the first half-year, and those who have done good work (G or E) during the first semester. Those in the lower group will be taught five days per week one period per day these periods to be used for lecture or demonstration or both, as deemed advisable by the instructor. The better grade pupils will have two laboratory periods, two days each week. All demonstration for class pupils (B) to be observed and recorded by pupils in the observing class. Of course, allowance will be made for possible pupils who have not received good grades the first semester, to be enrolled in these special laboratory classes. This would apply to those who were planning a scientific course in college.

Thus the major portion of work, from the standpoint of administration, will consist of putting good pupils in one section and poor pupils in another. A change has been made in pupil-periods per week, which may cause some inconvenience in schedule making.

Much should be gained by making the change. (1) It is from the G and E pupils that hopes for winning competitive scholarship examinations must come. (2) To those pupils who have some scientific future, maximum time for laboratory work and study can be given. (3) When the system becomes generally known and understood by pupils during the first semester of each year, much stimulus to all those pupils will result. (4)

Increased time will be afforded the instructor, in order that he may concentrate on every phase of laboratory work, to the decided advantage of these better-grade pupils. (5) Poorer types of students, who can learn very little, if anything, in trying to run their own experiments, will be decidedly "better off" under this system, but will have been given a fair chance in the laboratory the first semester. They will be able to clearly understand the method or technique, and the purpose of every part of each experiment, for the instructor will be running and explaining it. (6) If this system reduces the size of the laboratory classes composed of high-grade students, and it should, a decided increase in the type and amount of experimental work will result.

(7) By decreasing the number of pupil periods per week for the poorer pupils, size of these classes will be reduced, and more chemistry can be taught, and be taught more efficiently, since these pupils should benefit from the handling of apparatus by the instructor.

(8) A spirit of research can be stimulated in every pupil chosen to receive the special laboratory training. The laboratory class into which these pupils are placed will be very small. Their work may be done faster and at greater efficiency than at present; they will receive maximum opportunity to work at their own rate of speed; experiments requiring more thought, more time, can be introduced, and pupils will thus be thrown more and more upon their own initiative and resourcefulness.

Possible "Redistribution" of Pupils

100 pupils are enrolled in 312 B classes.

28 of these pupils are of G or E caliber. These 28 pupils to be divided into 2 laboratory sections of 14 each, but combined in one lecture class.

72 pupils remain, who may be divided into two classes to be taught 5 periods per week by the lecture-demonstration method.

Pupil teacher ratio old system }Same
Pupil teacher ratio new system}

Teacher periods per week old system..........................21
Teacher periods per week new system.........................21

2 "class B" classes 5 periods per week each.................. 10
1 "class A" class 3 periods per week each...................   3
2 "class A" laboratories 2 periods per week each............   8
                                                              ──
Total teacher periods per week new system................... 21

Let's stop trying to make the "silk purse out of the sow's ear," but let's also take full advantage of our rather meager crop of silk thread.

BIOGRAPHY AND HISTORY IN SCIENCE TEACHING

By C. Harrison Dwight
University of Cincinnati, Cincinnati, Ohio

Albert Abraham Michelson (1852–1931). Professor Michelson does not need the verdict of history to assure his greatness as a scientist. During his lifetime he was unanimously regarded as one of the foremost investigators of the world in the field of physics in general, and in light in particular. He taught of light, studied light, and experimented with light. He accomplished what had never been even attempted before. He measured the velocity of light with amazing accuracy, vastly improved the diffraction grating, and invented a new type of interferometer. With this instrument he calibrated the standard meter, measured the rigidity of the Earth, determined the diameter of stars, and carried out a search for a possible ether drift. His interest in light led him into a study of the colors of birds and insects, into form analysis, and made of him a watercolor artist of no mean ability. Personally Professor Michelson was very reserved, simple-hearted, and fearless. He carried out his experiments with sureness, care, and an almost uncanny intuition of the true physics of the problem. His results were accepted without question by the scientific world. His attitude of unrelenting rigor was the inspiration of the great, and the despair of the mediocre. As a lecturer he was clear and deliberate—allowing the class time to copy down the diagrams and mathematical equations as they came from his hand. The writer recalls an incident that occurred near the Ryerson Laboratory, University of Chicago, that illustrates the innate simplicity and kindliness of Professor Michelson. A rather bedraggled man, leading a large black dog by a rope, came along the sidewalk, inquiring the whereabouts of the Zoology building "where they buy dogs." Unwilling to encourage the man in his mean transaction, the writer refused to give out the required information. As the man shuffled away, Professor Michelson, leading his own happy Airedale, sauntered by. Pointing contemptuously towards the retreating figure of the bedraggled man, the author told Dr. Michelson the story. He listened attentively and sympathetically. "I don't blame you!" he replied, and walked on towards his office.

From these examples of the way in which scientists can be made real to modern students, we hope the teacher of science can gain some help in dealing with similar situations. Technical descriptions of original apparatus, methods of experimental procedure, and other non-personal matters need not be given in a biographical sketch. In fact, they tend to distract the pupil's attention from the *man himself*. We feel that the latter, once sympathetically understood, makes the former more readily comprehended.

We would like to close with a quotation from a well-known scientist regarding the possible social effects of science. At the Nobel Conference in 1903, Pierre Curie said:

> It is possible to conceive that in criminal hands radium might prove very dangerous, and the question therefore arises whether it be to the advantage of humanity to know the secrets of nature, whether we be sufficiently mature to profit by them, or whether that knowledge may not prove harmful. Take, for instance, the discoveries of Nobel . . . powerful explosives have made it possible for men to achieve admirable things, but they are also a terrible means of destruction in the hands of those great criminals who draw nations into war. I am among those who believe with Nobel that humanity will obtain more good than evil from future discoveries.

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THE STORY OF NATURE STUDY IN ROCHESTER, NEW YORK

By William Gould Vinal

National Recreation Association

Professor of Nature Education, Massachusetts State College

The glacier went. Life was more abundant. The elk, beaver, bison and wild pigeon lived, each after its own fashion. The Mound Builders and the Algonkians were no more. The five nations founded a Confederacy (about 1570) with codes of peace and justness. From the Finger Lakes to the Niagara Frontier 10,000 Iroquois abounded (1650). The Senecas planted corn, beans, squashes and tobacco. Throughout the Genesee Country there was food, industry, quietness, leisure pursuits, and happiness.

The forests were pushed back. The Jesuits kept valuable records. The bear disputed the rights of the cow and the Indian that of the whites. The Indians placed themselves under the Tories and Maj. John Sullivan led an expedition in revenge (1779). The wild game disappeared. Gravel pits appeared in the Pinnacle Range. Unlike Niagara the Genesee gorge became a dump. Lake Ontario received river waste.

A notable treaty was formed under the elms of Canandaigua (1794). The United States Commissioners and the Six Nations (The Tuscaroras had now joined) made a compact. The Indians reserved land.

New England pioneers came on foot, by ox teams, and in covered wagons. They dug a "Big Ditch" (Erie Canal 1825) to make transportation easy. There was no railroad, no postage stamps (not until 1847), no kerosene lamp. "New England" was a trade mark of quality. It guaranteed good schools, good homes and lasting friendships. It meant a direct tie-up with Yankee culture. It meant thinkers and doers.

A white girl was stolen by the Indians. They brought her to the Genesee Country. She became a child of nature and refused to return to the more artificial life of the whites. She wore moccasins by choice. She chopped her own wood for the fire. She pounded maize into samp, baked corn cake in the wood ashes, roasted venison in front of the fire and sat on the ground to eat it. She had something to think about besides the next movie. She appreciated self-control, prudence, fortitude and kindness.

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She was hospitable, generous and faithful. She lived to be ninety-three years of age. On March 7, 1874, the remains of Mary Jemison were removed from the Buffalo Creek Reservation to the Council House Grounds in what is now Letchworth State Park (1907). One of the most understanding addresses at the exercises was given by Doctor Liberty Hyde Bailey, of Cornell University. On the monument to this woods lady appears the following:

"To the memory of Mary Jemison, whose home more than seventy years of life of strange vicissitude was among the Senecas upon the banks of this river; and whose history, inseparably connected with that of this valley, has caused her to be known as 'The White Woman of the Genesee' (Mary Jemison, born 1742, taken captive 1755, died 1833)."

The days of superior wood craft disappeared. The kitchen garden, the pig sty and the cow pasture were no more. These went as did the tanner, the butcher, the miller and the candlestick maker. The wood ash gatherer, the wood sawyer, and the towpath driver went. Chores, homestead industries, and the family hearth-side were of the past. Hunting, fishing, chestnuting and tramping became less and less. The tin can age and the can opener appeared.

Nature living gave way to nature studying. John James Audubon (1785–1851) according to his journal had intended to go to Boston but money was getting scarce so he determined to "See Niagara." "Engaged a passage at seven dollars on a canal boat for Rochester, distant 268 miles—In six days I arrived at Rochester." These notes were under the date of August 15, 1824. One of the first nature students had arrived at new New England. It is of interest that about 1824 Audubon painted an oil portrait of Colonel Nathaniel Rochester (1752–1831). There is no record as to where the portrait was painted. The portrait of the Father of Rochester is owned by the Burlingham Collection, New York City.

The next year the Rochester Museum (1825–1852) was opened by J. R. Bishop "offering the naturalist, the philosopher, the Christian and the youth of the city a place of study, serious contemplation and amusement." As may be surmised, Bishop's Museum had curios, relics, fossils, skeletons, shells and wax figures. A traveling menagerie of living animals (1828) also appeared, "which the manager feels sure will interest all those who are desirous of improving upon the study of natural

history." This included the African lion, camel, dog-faced baboon, catamount, and a famous dancing monkey from Borneo. "Rattlesnake Pete" Cruber (1857–1932) said to be an authority on poisonous snakes, had a famous museum at 8 Mill Street.

A more serious form of nature study was offered by the Athenaeum (1846–1856). On its course appeared the names of Emerson, Horace Mann, Professor O. M. Mitchell on astronomy, and six popular lectures by Professor Louis Agassiz.

Out of this setting were to appear naturalists of world fame. Rochester was destined to be a city of Nature Culture. Lewis Henry Morgan (1818–1881) was born on a farm near Aurora, Cayuga County. As a youth he played with Indian boys. Later he was adopted by the Senecas. He was fortunate enough to attend the last council-fire of the League of the Iroquois all of which enabled him to write a classical scientific treatise on Indian life ("The League of the Iroquois," 1851). It was not until 1895 that ethnologists began to differentiate between Algonkian and Iroquoian.* The United States of Six Nations owned land from the Hudson to the Great Lakes. To them the family was unknown. Everything was in common. Their pursuits were hunting, fishing and agriculture. Morgan passed his summers recreating in northern Michigan. He went trout fishing for a time but soon substituted the study of the beaver. This made possible his "American Beaver" (Lippincott, 1868). He was interested in young men and in 1875 he was associated with them in reading Herbert Spencer. In 1879 he was honored with the presidency of the American Association for the Advancement of Science. He will also be remembered as the "Father of American Anthropology" and the discoverer of the "law of social progress."

The gold rush of '49 drew its quota of adventurers from Rochester. Among them was C. H. Woodruff. He was resting in a forest of Sequoias (1850) watching the large cones bumping to the ground. The squirrels were harvesting their winter supply of food. Woodruff placed some of the seeds in a snuff box. The Ellwanger and Barry Nurseries (1840–1917) planted the seed in their rose house (1855). As a result seven giant sequoia reached 60 years which was a notable indicator of an equable climate. These trees were winter killed in 1915 and soon after

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* Aboriginal Cultures and Chronology of the Genesee Country, Arthur C. Parker, Rochester Academy of Science, September 1929.

were cut down. Ellwanger and Barry were one of many nurseries which were attracted by the evenly tempered climate and the glacial lake bottoms. This company had 600 acres and employed 400–500 men. The lessons learned in the nurseries were taken to heart and carried home. The nurseries left an early imprint on the "Flower City."

Every scientist has heard of the Bausch and Lomb Optical Company. Twenty-six acres of plants, 3,000 workmen, 15 million eyeglass lenses in a year, microscopes for universities throughout the land, telescopes and photographic lenses is big business. In 1850 John J. Bausch borrowed $5.00 and set out for Rochester, New York. When he came to America in 1849 in his 19th year it took 49 days to cross the Atlantic. In 1853 Bausch opened an optical store. He built the first lens grinding machine in America. In 1872 Edward Bausch made his first microscope. During the World War the Bausch and Lomb Company had so perfected its work that it made about 70% of the glass received by the United States Government. How a foreign lad without money or friends built the largest lens industry in the world is a classical story.

Another Rochester business firm that has stood the test of generations of scientists is Ward's Natural Science Establishment, Inc. (1862). When a student at Williams College, Henry A. Ward walked 28 miles to Pittsfield to hear Louis Agassiz lecture. The same enthusiasm led him to Harvard to study under the great Agassiz. Young Ward was employed by Alexander Agassiz to collect Australian corals. Observations were made through a glass-bottomed boat. Upon discovering some extinct Megalosaurians at Rio de Janeiro he sent a detailed telegram which cost the younger Agassiz $328. Ward thought that the occasion called for an equally long reply. The answer as to whether the specimens were desired was "Yes." Ward was similar to Louis Agassiz in that it was difficult for his finances to keep up with his biological optimism. In the musty attic of the present day establishment may be found a small boat load of bones of an extinct Australian bird.

William T. Hornaday referred to Ward's as "The greatest scientific emporium in the world." Commencing with the Centennial in Philadelphia (1876) Ward sent extensive exhibits to the World Fairs. The first unit of the Field Museum of Chicago was purchased by Marshall Field for $100,000. It was Ward's World Fair exhibit. "Ward's" equipped the geology depart-

ment of Hunter's College. Today it is equipping Duke University.

On September 13, 1927, it began operation as the Frank A. Ward Foundation of Natural Sciences of the University of Rochester. "Ward's" skill in taxidermy led to the mounting of specimens for such leaders as Theodore Roosevelt and Carl Ackley. The museum was destroyed September 30, 1930, at a loss of $200,000. Although greatly crippled by the fire the establishment is a self-supporting unit of the University. The display of fluorescent minerals at the Metal Products Exhibit in the International Building, Rockefeller Center, New York City, is but one evidence of their keeping abreast of public interest.

Ward's *Natural Science Bulletin* first appeared in June 1881. It was the first bulletin issued by a scientific house in this country. It was edited by Frederick A. Lucas who later became the director of the American Museum of Natural History. In September 1936, Vol. X No. 1 was issued. It proposes to appear at monthly intervals. Ward's *Mineral Bulletin* is an informal publication for those interested in Mineralogy and is just starting on its fifth volume.

Henry A. Ward was Professor of Geology at the University of Rochester. During five years of oral teaching he took his students afield. Teaching was fascinating but a teaching museum was more fascinating. Known as the "Father of American Museums" he might also have been called the "Father of Visual Education." For generations of teaching his exhibits in natural history went to schools throughout the nation. Type forms, mineral cabinets, life histories of insects, plaster of Paris casts of celebrated specimens, and materials to present the idea of evolution were of great benefit to cosmopolitan American science. Ward's scientific, accurate and excellent workmanship won the approval of the school world.

Henry A. Ward rests in the glacial deposits of Mt. Hope Cemetery. As in the case of Wright of Oberlin his final monument is a jasper conglomerate boulder brought from Canada.

A third Rochester scientific firm to win universal confidence is the Eastman Kodak Company. Although many connect the name Eastman with music the word Kodak is almost synonymous with the word nature. The George Eastman big game collection, mainly from Africa safaris (1926 and 1927) made with the Martin Johnsons was presented to the Municipal Museum.

It was accepted in July 1935 and has been arranged for public view in the Peristyle Gallery in Edgerton Park.

Rochester is fortunate in possessing an Exposition Grounds. In 1846 the state built a reform school for boys at what is now Edgerton Park. It was called "The Western House of Refuge." Later the name was changed to the State Industrial School. There were 13 acres of land surrounded by a 20 foot stone wall. The school was moved and in 1910 the City obtained the property from the State. The first Exposition was held in 1911. In 1912 the northern half of building No. 9 was assigned as a Municipal Museum.

Since 1924 Doctor Arthur Caswell Parker, former State Archaeologist (1906–1924), has been director of the Rochester Municipal Museum. Doctor Parker was born on the Cattaraugus Reservation in Erie County. His early background plus experience as New York State Indian Commissioner (1919–1922) equipped him for the writing of various publications regarding the Indians, such as the "Seneca Folk Tales." Although he introduced visual materials for the Museum to illustrate the public school curriculum he is best known for his Indian work. In 1916 he received the Cornplanter medal for research work. The Rochester Museum is far from being a mere warehouse. With the opening of the new public library it is obtaining much needed space. It is a "going" concern in which the city can take real pride.

Dr. Edward Mott Moore (1815–1902) often referred to as "Rochester's most useful citizen" was a crusader for sunshine, fresh air, and clean milk. As a physician he knew the value of these and outdoor nature. Mayor Cornelius R. Parsons appointed a Board of Park Commissioners with Doctor Moore President (1888). As Chairman of the Park Board (1888–1902) he was champion of what then was an unpopular cause. He was unselfish in time and effort. He entertained Fiske, the historian; Stanley, the explorer, and Henry Ward, the Museum man. A quarter of a century after his death (October 29, 1927) a bronze statue was dedicated to him in Genesee Valley Park and he was heralded the "Father of Rochester's Park System." All credit should go to these men of vision who saw something of worth and devoted their time and strength to see that the ideal was realized.

Herman Leroy Fairchild (1850) was born at Montrose, Pennsylvania. At sixteen he taught country school and boarded

around among the farmers. He graduated from Cornell in 1874 and obtained the Doctor of Science degree from the University of Pittsburgh in 1910. He came to the chair of Geology and Natural Science at the University of Rochester in 1910. Harry A. Carpenter, Supervisor of Science in the Rochester Public Schools, credits Doctor Fairchild as being the most truly scientific of the men of that day and the only one that was outdoor minded. Doctor Fairchild made thousands of lantern slides and Mr. Carpenter remembers his saying that on Sundays, while his colleagues were studying religion from the Bible, he was studying the works of God. Fairchild's publications are authoritative for the physiography and geology of the Rochester district. His standing elsewhere is also guaranteed when it is known that he rewrote Le Conte's *Geology*.

Colonel Samuel Parker Moulthrop (1848–1932) was Principal of Number 26 school, which was called the Washington Grammar School. For over sixty years he was teacher and principal in Rochester Public Schools. Col. Moulthrop must have been a remarkable man and was half a century ahead of his time. He was "first" in so many things it seems to advantage to arrange his natural science achievements chronologically. The rapid succession of events in his life are a tribute to his unusual ability to bring practice abreast of theory. Col. Moulthrop was born near Oshkosh at the fork of two Indian trails when Wisconsin was a territory. His New England inheritance plus being a farm boy equipped him with a good mind and a liberal background.

1890—Natural Science Camp at Canandaigua Lake. Albert L. Aery, Professor of Science in the Rochester High School, was director. Mr. Moulthrop had charge of the military work and brought in considerable nature study. He was called "Commandant." He was next at the Y.M.C.A. camp for 15 years or more. In 1911 he delivered lectures on Woodcraft at the State Y.M.C.A. Camp Dudley on Lake Champlain.

1894—Began planting and dedicating memorial trees in Seneca Park. Col. Moulthrop often had 5,000 present at these Arbor Day celebrations in which the school children planted oak trees as memorials to War veterans. He had congratulatory letters from "Uncle John" Spencer of Cornell University. These plantings were distinctive in that they formed a grove, being one of the earliest efforts of its kind.

1900—School Gardens. Col. Moulthrop also had the first gymnasium and the first swimming pool in the city schools. This year he received a Gold Medal from the Paris Exposition for outstanding school work. He always had his office cluttered with minerals and Indian relics. Whenever he obtained a new cocoon, for example, he took it around to the rooms and held informal discussions with the children.

1903–1904—Civic Improvement. His school was in a poor section of the city. The children planted seeds near the curb. Later they took the flowers

to the hospitals. In 1903 and 1904 the street was planted for one half mile on both sides, 350 elm trees were alternated with poplars which were later cut so that the elms would have more room. Every one said that the children would pull the plants up but he developed civic pride in the children. One day a milkman tied his horse to one of the young trees with the result of breaking the top off a tree. The unfortunate milkman was nearly mobbed before Col. Moulthrop came to his rescue. He had the first regular medical inspection of pupils.

1908—First school nurse and first dental clinic.

1909—Named chief of the Senecas. One of first to introduce industrial and vocational training.

1910—Assisted in organization of first Boy Scout troop. He was first scout commissioner and was president of the council for seventeen years. Was called "Chief Scout" of Monroe County.

1914—First Superintendent of Playgrounds and Recreation. For ten years before was director of the Rochester Playground League.

Chester Dewey (1784–1868) graduated from Williams (1806). He was Professor of Natural Philosophy at Williams (1810–1827). In 1836 he moved to Rochester to become principal of Rochester Collegiate Institute. He gave popular lectures on science to the public and illustrated his talks with experiments and charts. He believed in living according to the laws of nature and often talked to his students on that theme. As a naturalist-educator he interested his students in the out-of-doors, particularly in botany. His hobby for over 40 years was a study of the sedges (1824–1866). In 1850 Professor Dewey was elected to the chair of Chemistry and Natural Philosophy, University of Rochester (1850–1860). Wood's *Class-Book of Botany* had the plants arranged in natural order and bore the following inscription: "To the Rev. Chester Dewey, M.D., D.D., Professor of Natural Science in the Berkshire and other Medical Institutions, author of the *Report on the Herbaceous Plants of Massachusetts, Monograph on the Carices*, etc. etc. This volume is respectfully dedicated by the author."

Rochester has a long list of nature-hobbyists who have pursued natural history for a pure love of it. Space does not allow us to even mention each representative. Doctor Samuel Beach Bradley (1796–1880) who lived in Monroe County (1825–1880) was an authority in botany. H. F. Atwood was the first in this country to discover the European Praying Mantis (summer of 1899).[*] The insect was probably introduced on nursery stock. F. S. Boughton is interested in mushrooms and has had several named after him. M. S. Baxter has a particular interest in flowering plants. Many of the present day citizens who are

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[*] M. V. Slingerland, Cornell University, *Bulletin 185*, November 1900, page 37.

interested in nature study are members of the Burroughs-Audubon Club which has a Conservation Station at Railroad Mills, New York.

Richard E. Horsey has charge of what may be the only city-owned herbarium which has a collection of the foliage and fruits of the woody-stemmed plants of the park system. Although not a college graduate he collected for Charles Dudley Sargent and is known and consulted by such men as Dr. Liberty Hyde Bailey and Dr. Harry Brown. His arboretum is visited by classes from Syracuse and Cornell universities. He is an authority in his line and hopes for the day when his herbarium will be fire-proof and can be made useful to the public and to schools. The Arboretum (1890) of the Park Bureau consists of 110 acres. More truthfully, however, the combined Rochester Park system may be thought of as a city-wide arboretum.

"Rochester Parks" is the title of a classical story. The Rochester park system is better known away from the city than at home. It dates back to the vision of leading citizens. Calvin C. Laney, engineer, made a preliminary survey and was appointed Superintendent of Parks in 1888. John Dunbar was employed as Horticulturist in 1891. Fredrich Law Olmstead, of Boston, was consultant. Since 1900 the city has been a recipient of rare trees and shrubs from Arnold Arboretum (1872) the largest tree park in the world. This also gave contact with Doctor Charles S. Sargent and Professor E. H. Wilson—men notable among students of trees.

Wilson in his four botanical tours to Western China and along the Mountains of the Thibetan frontiers was credited in *World's Work* as having brought back to America more woody-stemmed plants than are native. There are said to be seven wild species of rhododendron on the North American Continent. Wilson discovered rhododendrons new to science. These do not thrive in limestone soil but grow luxuriously at Durand-Eastman Park in the silts and clays and on the Genesee delta built in Ancient Lake Iroquois. Dr. Sargent collected seeds of the Common Lilac (Syringa vulgaris) along the banks of the Danube. William S. Clark, the first president of Massachusetts State College at Amherst, sent the tree lilac (Syringa Japonica) from Northern Japan. This lilac grows 30–40 feet high and is the last of the tree lilacs to flower. Space does not allow the telling of the romance of the 363 kinds of lilacs to be seen on the gravel moraine of Highland Park or the 550 Hawthorns in

Genesee Valley Park. The accumulated story would fill a book that would read like a novel.

The average data for the blooming of the Rochester lilacs is May 20. On "Lilac Day" the Lilac Queen is chosen on the basis of personality, poise and charm. Like cherry blossom time in Japan, lilac time in Rochester is an occasion for festivity. It has come to be known as "Lilac Week." Rochester people no longer seek a pot of gold at the foot of the rainbow for it is in the parks. A civic consciousness and pride in lilacs has been so developed that lilac vandalism is absent.

"Blossom Time" in the fruit belt is now being advertised by the Lake Ontario Country Association which also interests itself in parks and intercommunity relations. It is contemplating a scenic highway from the Niagara frontier to the St. Lawrence River. The Association has never had paid officers or workers. Fruit blossom time and lilac week are only the beginning of a continuous plant pageant. The rhododendron-azalea display comes about June 17.

The color spectacle extends into the fall when dogwoods and viburnums are at their best with their bright foliage, fruits and stems. The tupelo, sorrel tree, apples and cherries add to the color. In winter there are white firs and blue spruces from Colorado, Mugho pines from Central Europe, Scotch and Austrian pines that can stand the cold winds, and the Japanese yew which is as hardy as the Canadian yew. Rochester believes in flowers for the living. She has no use for "Keep off the Grass" signs. And thus the "Flower City" rightly earns its name.

Rochester also has a program for street trees (since 1891). It is estimated that there are 65,000 street trees. Their welfare is the responsibility of the Park Department. Rochester is suffering from growing pains. The widening of streets means tree cutting. If Rochester is to remain a forest city, if it is to maintain tree respect, it must guard these gifts. The City Forest consists of 4,000 acres, forty miles from Rochester at Hemlock and Canadice Lakes which furnish the city water supply. The first forest of this unit was planted in 1902 and now over a million trees have been set out.

The spread of the park idea did not actually get beyond the confines of the city until the formation of the Monroe County Park System October 2, 1926. The first County Park—Ellison Park, was opened and dedicated October 1927.

The pre-glacial Genesee River emptied by the Irondequoit

Valley into a huge arm of the sea. During the ice age the glacier dumped a large cargo of sand and gravel near Rush. The Genesee was forced to cut a new channel—the present gorge and its falls—to the lake. This was the time of the birth of Mendon Ponds. Fortunately this area has been preserved for all time.

The Mendon Ponds Forest and Game Reservation, 11 miles SE of the city, is a shrine for the naturalist. Here are 1,563 acres of pond and meadow. Every stage in the life history of a kettle hole, from a deep pond to the formation of a cold sphagnum bog, exists. Each bog is a refrigerating spot with a touch of Labrador scenery with its cranberries, leather leaf and Labrador Tea together with rare orchids. The more adventurous may see sundews, bladderworts, and pitcher plants. On one of the hilltops I found a stand of bayberry over six foot high and with trunks the size of my wrist. Stone artifacts indicate that the park is the site of an ancient Algonkian Village. So many pheasants were released in the neighborhood that the farmers complained. Mallards, Canadian Geese and Bob Whites are being propagated at the present time.

The first State Fish Hatchery in New York (1870) was built at Caledonia, 16 miles out of Rochester. Seth Green, the "Father of Fish Culture" was the first superintendent. Rainbow and brown trout are the species commonly raised. In the last decade Rochesterians have not only been thinking countryward in the way of parks but have moved out to garden homes. Most of them are commuters who seek larger lawns and gardens, shade trees and quietness in more healthful and more beautiful open spaces. This love of nature means greater social security, more attractive homes, and planned leisure. The movement parallels the more recent garden cities such as Mariemont near Cincinnati; and Radburn, New Jersey.

It has taken a great deal of foresight, judgment and energy to proceed from the "Public Square" day, where one could hitch his horse and buggy, when he came to town to shop, to the great network of parks and boulevards that are attendant to the large metropolis of today. Nature recreation is one of the fastest growing services. As one scans from the more central, bald playgrounds with artificial amusement to the peripheral areas of nature recreation he must note certain trends. As one passes from the neighborhood playground to the City Park— and that can usually be done "via hoof" he must observe that there is less play apparatus and machinery, less amusement

features, less spectatoritis, less baseball, and less vandalism. Further out are the County Parks, which are reached any day via auto. They are the spots for church picnics and family outings. There is more beauty, more individuality, more "living," more nature recreation, and more refinement in these areas. The State Parks are holiday parks reached by automobile. They are free of the mechanical and artificial. They are even more restful. They are clean and free of hoodlumism. They have nature trails and trailside museums. City nature recreation is going to be ever outward to the forests and open spaces.

There are 13 State Parks within 45–100 miles of Rochester with a great variety of scenic-historic and recreational attraction. These parks have a conservation plan which includes water, soil, timber, fish, and game. With the spread of cities we can look on the County and State Parks as seats of future nature recreation. The automobile will make this possible and railroads for the most part will continue to make our National Parks places of nature recreation in the superlative. In each case the city taxpayer will be asked to meet his share. The past decade has been one of acquiring these outdoor school rooms. The next decade will be one of teaching people what to do in these play areas. That calls for planned nature recreation.

We have already seen how Col. Moulthrop recognized the value of nature study activities. Howard Eaton in 1900 taught in the Bradstreet Private School for Boys. He is best known as the author of the *New York Bird Book*. Possibly he has contributed more than anyone else to bird study in New York State. It remained for Harry A. Carpenter to organize elementary science in the schools on a systematic basis. In 1915 he started science work in the Junior High School. Informal science is now presented in all the Junior High Schools in the form of clubs with the teachers as leaders. Every pupil chooses a club. They all meet at the same hour. In 1925 Mr. Carpenter was relieved of Senior High School teaching to give full time to supervision. Since then he has also given teachers training courses at the University of Rochester. He is a member of a general committee (1929) which is working on a twelve-year science program. His radio periods (February 1933) have been a real achievement and now include the fourth to the seventh grades. Teachers below this level are free to introduce incidental nature study. The high schools are in an exploratory stage. East High uses the unit method. Instead of being separated into

subjects there is a series of units such as found in life. John Marshall uses the Dalton plan. Such procedure requires state sanction and the cooperation of the College Entrance Board and is in a healthy and progressive situation. Mr. Carpenter's series of science books for seventh, eighth and ninth grades entitled *Our Environment* (Allyn and Bacon, 1928) have passed the million mark in sales which is a good thermometer of how the school world estimates his work.

Nature recreation in Rochester involves five distinct organizations: the parks where it will take place, the schools where it will take form and meaning, the public museum where it will be made scientific, the playground where we may look for outdoor leadership and clubs where it provides for adult participation. Municipalities by building conservatories, zoos, parks and playgrounds whether they know it or not are making nature recreation a public utility which involves community welfare, citizenship, and beautiful homes, as well as health. On the first playgrounds of Rochester chestnuts were free to everyone. So were hickory nuts, butternuts, hazelnuts and wild grapes in season. The orchards offered apples, pears, peaches and cherries. The Erie canal, which geographies described as the largest canal in the world, offered unparalleled opportunities for short excursions. In downtown Rochester nature has been reduced to a few "tree islands." Children of nature cannot thrive on playgrounds that are deserts of brick and asphalt. We are just beginning to find out that vegetation is not mere haberdashery but a matter of steadying the nerves. Plants are a necessity and not a luxury. Rochester has done well in her parks and Rochester must do well by her playgrounds. Rochester must progress as well as grow. The same power of vision that was used in 1888 must be used in planning in 1936. Rochester children must not only have lilac respect but hedge and garden respect. They must be familiar with nature's laws that tell us for example that clams, kittens and babies must have a lime diet to build a good skeleton. They must see that resemblances between a Chinaman, African and White are more remarkable than the differences. Thick lips, wooly hair, blue eyes and red hair are trifles. We are all brothers. In these days children need to deal with things that are based on evidence. Propaganda disregards evidences. The success of a garden is based on facts. Rochester has superb outdoor nature areas. Rochester has more than her quota of nature classics and nature heroes. Planned nature recreation must come.

A METHODOLOGY OF GUIDANCE FOR TEACHERS OF SCIENCE AND MATHEMATICS*

By Ralph C. Bedell

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Each teacher of science and mathematics hopes that his students will be successful but he *knows* that many of them are doomed to disappoint their instructor and themselves as well. A few fail in the sense that they do not receive a passing mark. Many who have their passing marks permanently inscribed upon the registrar's golden book of knowledge will fail in their personal and vocational adjustments to the scientific and mathematical factors of environment. For in the minds of many students, and not a few instructors, units, credits, points, and semester hours are more important than knowledge and skill. Some students will make remarkable successes, some because of excellent instruction and some in spite of our systems of training and methods of instruction. Far too frequently, the teacher concentrates instruction upon science and mathematics morons to the extent that capable students satisfy themselves and the faculty with mediocre accomplishments. Society thus has thrust upon it, on the one hand, those who dislike and avoid things scientific and mathematical; while, on the other hand, it places in unimportant and subordinate positions those who could have made remarkable contributions to our scientific and technological development. This is true, in spite of the fact that the scientists and mathematicians and their legitimate offspring, the engineers, have been major factors in making this age the most outstanding in history.

Why do so many students receive only the shells of our great technological development when the pearls apparently are placed before them within easy reach? A part of the answer to this question is to be found in our educational system and methods of instruction. Another portion of the answer is to be found in our selection and guidance of those students who need and seek knowledge in the sciences and mathematics. Although both phases of the answer must go hand in hand, it is the purpose of this paper to discuss primarily the guidance and selection factors.

Perhaps we can obtain a better picture of the problem if we mentally transport ourselves to the office of the high school principal or the college dean. It is registration day. Young America is going to school. One by one, each human personality files by to receive his academic prescription. The diagnosis usually goes something like this: "Well, what do you think you'd like to do? What school grade were you in last year? What grades did you receive in your courses? What teachers do you think you would like? So you think you'd like some science and mathematics. Fine, here are your courses. Next student, please." You may think that this is an oversimplification and a rather perfunctory examination upon which to base such an important prescription. Really, though, the examination is of relatively little importance because the curriculum committee, the state superintendent of schools, and the state university have already indicated certain required curricula which the student must take. In effect, the student has been educationally diagnosed and prescribed for by people who never saw him, never hope to see him, and don't care to see him. All too often the student realizes the truth of this situation and accepts his program in a perfunctory manner.

The student is not greatly concerned about the registration because he knows that the chances are quite high that his course will be taught by an instructor who either slavishly follows a textbook or just as slavishly follows a course of study prescribed by the same almighty educators that prescribed the curriculum.

It is interesting to notice here that many students do profit highly from this type of prescription. The important point and the one which this paper proposes to emphasize is, however, that such a process as this inevitably dooms many students to receive courses and types of instruction for which they are not well adapted. In too many instances, the teachers of science and mathematics have cooperated in this type of enterprise.

We have sat in the game of educational poker with the rest of the educators and have played or bluffed our usually good hands so well that science and mathematics almost universally have places in the required curriculum. I do not wish to object to our success in playing the game, but I do wish to carefully examine the rules by which the game is played, with the end in view that we might change the nature of the game entirely or at least insofar as the rules fail to fit learning situations.

Teachers of science and mathematics, as is the case of other teachers, have attempted to make their curricula of instruction conform to the hypothetical average student. It is true that we recognize certain outstanding students who possess high ability or who are outstanding for their lack of ability, but it is also true that we are seldom enabled to teach effectively the people who deviate widely from the norm. On the other hand, we are frequently placed in a position of inviting them to eat at an academic table which they are either too short to reach or for which they have long since grown so tall that they can no longer sit in the chairs that are around the table. One is forced to become a Lazarus and accept the few scraps that fall from the academic banquet. The other is still hungry after having consumed all of the food on his plate.

Within the last quarter of a century, research workers in psychology and education have taught us certain crucial facts which could be applied to assist us and our students to find ways out of the dilemma. It is well known that a student's claimed interests never, in and of themselves, are adequate reasons for prescribing curricula or instruction. In the minds of far too many teachers, the false doctrine still persists that if a student earnestly wants to do a thing, he can do it. Motivation is necessary for learning, but motivation by itself does not guarantee learning.

For nearly a generation, the "wide extent of differences among students" has became an integral part of the habitual speech patterns of educators. Although the teacher hopes that all of his students will succeed, it is almost axiomatic that he will find wide differences even in a small class and that he should adjust his instruction to those differences. We teachers of science and mathematics are forced to take a scientific attitude toward the problems of education. We must conclude that there should be different types of education in science and mathematics adapted to different types of students and their various cultural and professional needs.

While this philosophy of education has been well accepted by science and mathematics teachers, it has not so far led to practice based upon its deductions. Clearly enough, this is the precise point where our speech habits should be translated into action instead of leaving us to procrastination and delay. The science and mathematics teacher will demand that we have a scientific analysis of aptitudes, interests, abilities, and needs

of students before we prescribe their curricula and determine the instruction to which they shall be exposed. For our training to be effective, it must first be determined what materials of science and mathematics a student should know and how much of it he is capable of learning.

But is there a methodology whereby our science and mathematics education can be adjusted to the individual interests, abilities, aptitudes, and needs of our students? A casual reading of the field of education during the past two decades should be sufficient to show that such a methodology is available. Dr. E. G. Williamson has shown that the essential points of this methodology are:

1. Measurement of the factors that influence success in science and mathematics.

2. Diagnosing each student in terms of these factors and his needs.

3. Prescribing an education in terms of the diagnosis.

4. Continued counselling to check the effectiveness of the prescription, the accuracy of the diagnosis, and to make such modifications as seem necessary.

Let us examine the extent to which such methodology may be applied in the teaching of science and mathematics.

First, let us consider the problem of accurate measurement of pupil aptitudes, abilities, past learnings, and interests. To a large extent the present prominent place of science and mathematics in the school curriculum is due to the fact that scientists and mathematicians have insisted that their subject matter is based upon accurate measurement. Science has become wedded to mathematics because the mathematicians have furnished the major tools whereby science has been able to achieve its present high state of perfection as a body of subject matter. Science and mathematics teachers have been justly vigorous in their claims that students should come in contact with accurate measurements and thereby acquire the attitudes and methods of thinking of our scientific minds. We have wholeheartedly accepted as a basis for our subject matter the idea embodied in the statement by Clerk-Maxwell, "I often say that when a thing can be measured we can know something about that thing, and until it is measured we know little or nothing about it." It is a most peculiar phenomenon that teachers of science and mathematics have placed such stress upon teaching the student to measure items of his physical environment, and at the

same time the same teachers have been content to avoid accurate measurements of the learnings of these students. Is it any wonder that educators and psychologists frequently have made the statement that science and mathematics teachers are among the most unscientific of teachers?

Students are measured with rubber meter sticks that stretch back and forth for different students and change in length from teacher to teacher. It is well known that students who have a strong desire to make the honor society or Phi Beta Kappa frequently do so by the selection of courses and teachers where grades are easy to get. The teacher who refuses to let his personal and emotional prejudices influence the marks he awards his students is rare, if not entirely nonexistent. Yet these marks are the measurements by which other people judge the science or mathematics knowledge of the students. Even more significant, such marks are the principal means whereby the student determines whether or not he will go on with more science or mathematics. They are, in most cases, the measurements by which the student guides his future educational and vocational activities. Educational and vocational choices based on such measures can not be more accurate than the measurements. The fact that students make so many unwise choices is to a large extent the direct result of the inaccurate measurements which we furnish them.

The accurate measurement of students depends upon the use of carefully and scientifically designed tests which make it possible to rate each student in comparison with national norms. Such tests must be constructed in terms of the best knowledge of science and mathematics education to make sure that they actually measure those things which they should measure. They should also appear in new comparable forms each year to permit reapplication of the measures. Such repeated measurements make it possible to determine the influence of instruction that has been applied during the interval between testings. Thanks to the statistical tools borrowed from the mathematicians, it is possible to establish national norms from which reasonably constant measurements can be obtained. Test services of this nature are now being supplied by such agencies as the Cooperative Test Service and the Iowa Every Pupil Contest Examinations.

It is impossible for one who has read the educational literature to overlook the defense mechanisms which teachers and

administrators have built up toward such standardized measuring instruments. There are some who fear that such tests will standardize instruction in the direction of a mere fact giving and fact reproducing process. It is significant to notice that these same people would not buy a suit of clothes from a tailor whose yard stick fluctuated from customer to customer and changed from time to time with the same customer. They would not buy sugar from a grocer who selected a pound weight which varied with each purchaser. On the contrary they demand, by law and severe penalty for violation that the butcher, the tailor, the grocer, and even the candle-stick maker comply with the regulations established by the Bureau of Standards. Science teachers are so familiar with the significance of such phrases as "U.S.P.," "C.P.," "Commercial," and "meets U. S. Bureau of Standards Specifications" that it is unnecessary to carry the comparison further. Whether or not tests overemphasize fact getting on the part of the student depends upon the skill with which the tests are constructed. Since this phase of the problem has received adequate discussion elsewhere,[1] it is not necessary to devote more time to it here.

With respect to the value of such tests, educators divide themselves into two classes. One group points out that any single test will not increase accuracy of prediction more than about twenty per cent, while the other group insists that twenty per cent accuracy is much better than zero per cent. We do not discard the automobile because the efficiency of the gas engine seldom exceeds twenty-five per cent, nor do we hesitate to make use of the locomotive because steam engines are usually less than ten per cent efficient. It is doubtful if an accurate measurement of the entire educational system would show more than twenty per cent efficiency.

It would, therefore, seem wise to make the best possible use of the test instruments at our disposal.

The use of such tests demands a certain amount of specialized study and skill much as the use of instruments in the science laboratory demands specialized study and skill. It is necessary that science and mathematics teachers know both the value and limitations of the test instruments that are employed. In this respect the guidance of students in science and mathematics as well as other fields becomes an applied science in much

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[1] Williamson, E. G., "The Cooperative Guidance Movement," *School Review*, Vol. 43, pp. 273–80. April 1935.

the same sense that engineering and medicine are applied sciences. Engineering and medicine are of no value unless the basic scientific facts upon which they depend can be interpreted in terms of the specific task or patient under consideration. An important step in successful engineering is an adequate diagnosis of the nature of the problem to be solved. An essential step in the doctor's treatment of his patient is an adequate diagnosis of the patient's illness. Guidance must depend upon correct diagnosis.

We come, therefore, to the second step in our methodology of guidance, namely diagnosis. An adequate diagnosis demands the measurement of all of the significant facts about a student and their interpretation in terms of the needs of the student. We must consider in addition to his test results, such factors as health, financial ability, family background, personal prejudices, ambitions, teachers' marks, and cultural and vocational needs. Such a diagnosis is greatly facilitated if information regarding these traits is collected and cumulated over a long period of time. Data gathered at any one time provide a most valuable snapshot picture, but a collection of such snapshots over the entire school career would permit us to approximate a motion picture whereby trends of development would be shown in bold relief. The best means for obtaining such a motion picture is the thorough use of a cumulative record such as that supplied by the American Council on Education. Such a cumulative record supplemented by anecdotes describing significant behavior of the student would provide the surest means known whereby the proper educational prescription could be made.

Third, our methodology demands that education be prescribed in terms of the diagnosis. This means essentially that learning should be required in terms of the abilities and needs of each student rather than in terms of the opinion of some committee or educational standards group that knows nothing about the student. Notice that I have said "learning" instead of courses. It is well known that taking a course does not guarantee learning, nor does absence from a course guarantee ignorance of the course. The prescription should depend to a large extent upon what the student knows about science and mathematics and what he is able to learn about them.

The educational prescription should consider the vocational needs of the high school and college student. In the cases of most vocations involving science and mathematics, the student

must first master subject matter in these fields before he can enter the vocation. The successful engineer must first be a successful student of engineering. The doctor must first be a sucessful student of medicine. The mathematician must first be a successful student of mathematics. The problem of vocational choice in science and mathematics, therefore, can give way temporarily to the prognosis of successful studentship in the training necessary for the vocation.

The fourth step in our guidance methodology is continued counseling. The successful doctor makes frequent visits to his patients to determine the effects of his prescriptions and the accuracy of his diagnosis. He knows that though his diagnostic instruments are good there may have been some factor which he overlooked or which had not been adequately considered. There may occur from time to time new factors. It is necessary to consider all of the facts, balance one against another, and make the best possible diagnosis. Furthermore his patient is an individual and it is necessary to determine the extent to which this patient deviates from the norm of other similar patients. Good guidance in science and mathematics must follow essentially the same procedure.

The educational prescription must, in the last analysis, depend upon the teacher's judgment, which is based upon all of the facts available. Such judgment is open to error in the same manner as the doctor's prescription is open to error. Continued counseling will enable the skillful teacher to discover causal factors which had not hitherto appeared, and will make possible the discovery of errors in teaching methods and selection of materials of instruction. Counseling of each student at least once a month should be as firmly established in our educational rituals as registration at the beginning of each semester.

This methodology of guidance in science and mathematics thus becomes an application of the scientific method to our educational processes. First, accurate data must be collected about the problem of student success. These data must depend upon accurate measurement of the essential learning factors of *each* student. Second, we must make a diagnosis on the basis of these data; that is, we must develop a theory which seems to offer the best chances for solving the problem. Third, we need to make educational prescriptions in terms of our diagnosis. Fourth, continued counseling is necessary in order that we may check our theory of diagnosis, and modify our educational

prescriptions in terms of the effects on the students. The skillful application of this methodology of guidance will make the teachers of the basic sciences the most scientific teachers.

A NEW METHOD IN TEACHING PHYSICS

By Herschel Newton Scott
Lane Technical High School, Chicago

We teachers of laboratory science usually have a personal interest in our subject which goes much beyond classroom requirement. Our common error, however, is to assume a like spontaneous interest on the part of high school boys and girls. These youngsters who drive fine automobiles may have mastered all that is within the tonneau of the car: the brake and clutch pedals; the steering wheel; and particularly the horn and the accelerator; but many of them have not the least concern about what is under the hood. Their interest in the radios in their homes may end with the switch and tuning dial. All the rest is out of sight and, I fear, out of mind for many of these children who live in the age of science.

This casual attitude of pupils toward the greatest inventions and discoveries of the recent past is accepted by experienced science teachers as an exasperating but prevalent condition, which must be met by making the subject more attractive and more interesting. Declining enrollment in physics classes in schools where the subject is not required for graduation can leave no doubt as to how the pupils feel about physics.

The "new method" in our title, is not really new, except in the sense that one can nail several old boards together to make a new box.

A starting point in this method is an examination of the apparatus we use in physics. Laboratory apparatus should be large enough and showy enough to command respect and attention. However, a good share of regular physics equipment is so small, so "dinky," that it is actually unworkable.

For years the lever used to illustrate the laws of the lever has been a meter stick, a frail piece of maple, nicely varnished, and marked off in centimeters and millimeters. It is a measure, of course, and should be used for no other purpose. The practice, however, has been to clamp a fulcrum to it, with set screws

which destroy the finish and the graduations on the rule, to suspend it from a ringstand, and hang tiny weights on each side of the fulcrum, thus bringing it to a balance. If your breath falls directly on this outfit, it collapses.

There is nothing here to hold the interest of a healthy boy or girl of high school age. Watching their expressions as this demonstration is in progress, I believe I get their reaction,—teacher is up to small business. The danger is that the pupils will feel the same contempt for the science of physics. Why do we use these toys in the teaching of a robust science like physics? I suppose a few teachers think it is vulgar to use the real thing rather than a miniature. To such persons science is not reality. But how did Archimedes regard it? You remember, he rigged up a system of levers and pulleys so that King Heiro of Egypt was able to move a large ship with the force of a single hand. He said: "Give me a long enough lever and where I may stand and I will lift the world."

To Archimedes a lever was a wooden beam. It is that or, possibly, a crowbar to anyone who has any practical knowledge of levers. So why not have a real lever in your laboratory? If you are interested, here is a way to make a good one. Get a two-by-four of well-seasoned cypress not less than ten feet long. Cypress is a good wood to use because it does not warp easily, and the mills dress it up more smoothly than other woods. You should have very little sanding to do if you make a good choice at the lumber yard. For the fulcrum you will need a one foot length of one-half or three-quarter inch steel rod. Now find the center of the beam by balancing it very accurately over the edge of a level table, the two inch side of the beam being uppermost. Rule a line along the four inch side at the table edge, or point of balance. Then, centering the bit on this line and $1\frac{1}{2}$ inches from what will be the top of your lever, drill a hole through the beam just large enough to take the steel rod by driving it in. Now you can finish off the beam. Paint it a glossy white, with black painted graduations for feet and inches on one side, and meters and centimeters on the other. These marks should be large enough to be seen clearly from the back of the room, and their position should be checked with a steel tape or the most accurate rule you have. Below the graduations screw into the bottom of the lever two inch screw hooks for the hanging of weights. Now we come to the support for the lever, which is easy if you have a sturdy overhead structure to your labora-

tory tables. Drop loops of wire from this to each side of the fulcrum so that the lever will hang about 18 inches above the tables. If you care to make a base support for your lever, I suggest that you use an iron kitchen stool. If the rungs are wide enough, you can drill them to hold the fulcrum. There it is finished. You may think it took a lot of work, but remember it is good for twenty years. It's hard to tell how many meter sticks it will save in that time. The important thing, of course, is that you now have a lever. Your dullest pupil will know that he is face to face with a lever when he first sees it. Furthermore, and you must try it out if you doubt me, he will understand the law of the lever when he finishes the experiment. Pupils enjoy using this lever. Their fingers itch to get hold of it. It is an impressive sight. A boy once told me: "When that lever tips, the whole building seems to tip with it."

We should mention the weights used in the lever experiment. Accurate weights bought in sets are quite expensive. A laboratory needs only two or three such sets for small accurate weighing. Almost all experiments can be performed with even a lower per cent of error using coarse hook weights, ranging in size from ten kilograms to fifty grams, provided they are large scale experiments on sensitive apparatus, as in the case of the big lever. For many experiments in which large weights are necessary, I use lead shot in half-gallon molasses buckets. These are weighed on a large balance so that no accuracy is sacrificed. The balance I use is a gymnasium scale weighing up to 150 kilograms. I consider this scale indispensable.

I shall run through a number of other experiments which, like our lever experiment, can be put on in what I call the "grand style." In a few instances the "grand style" is hard to achieve. Manufacturers of thermometers, for example, place a limit on the size of their product; although I did have my eye on the 100 foot Havoline thermometer at the Chicago World's Fair. You recall the widespread interest in this giant thermometer. A common enough sight, one would suppose, but I really believe that many thousands of people who saw it were actually *seeing* or perceiving a thermometer for the first time in their lives.

Another machine experiment which is the bane of every physics teacher's life is that with the wheel and axle. The stock wheel and axle bought from the supply houses weighs about a pound. The "rope" to be used with this plaything must be

twine or light cord, and a load of a kilogram will wreck the whole set-up. This "machine" is expected to show the pupils the action of the capstan which hoists up the several-ton anchor of a ship, or the winch which draws the ship up close to the dock. If the pupil really learned these intended applications, we should have here a remarkable example of transfer of learning. Actually this futile toy raises more problems in the minds of pupils than it solves. Using this device, the conscientious pupil will get results showing up to 15% error.

You may ask why larger and better apparatus of this sort cannot be bought. The answer is there is not enough demand for it. Too many physics teachers are satisfied with what they have. So you must make it yourself if you want equipment of working size. It is a mistake, of course, not to use the ingenuity and skill of your pupils for this task. For example, two senior boys made a wheel and axle which has been the pride of my laboratory for five years. They made it from two pulleys which they found in a junkyard. One pulley is 24″ in diameter and the other 6″. The two are mounted on an axle which has for its bearings the front-wheel bearing assemblies of a car; all of which was junk. This machine is highly sensitive and handles a load of 50 kilograms with ease. We use braided picture wire to support the load.

None of the other simple machines can be adequately illustrated by apparatus now available at supply houses. Your hardware man may help, however. To illustrate the screw, there is nothing better than a real jack-screw. For pulleys, get a six strand block and tackle. For the inclined plane, a board, 2″ × 8″, and as long as it can be for you to store it conveniently. You can use this same board in work on the laws of falling bodies.

It is in the heat experiments that the failure of our tiny equipment is most apparent. Here, always, the most active participant in the experiment is the temperature of the laboratory. Its effect cannot be determined nor can it be compensated for with any accuracy. The few swallows of hot or, it may be, cold water in the calorimeter cup are constantly being brought to room temperature, the poor insulation presenting little opposition. Thus, heat losses or gains are very great and often make results entirely worthless, when such small amounts of water are used. Most intelligent teachers of physics have long ago discarded the inner cups of these calorimeters. They use

the outside can with the wooden cover, and insulate the can by wrapping heavy folds of newspaper around it. Then they use just as much water as the can will hold without risk of spilling. In this way the per cent of error can be reduced to one-fifth what it is when the inner cup is used. Even better results can be had, however, if a larger can is used. I have found that at least two liters of water should be used in all experiments with a calorimeter.

The little copper boilers commonly used to produce steam are pitiful in appearance and in performance. All my sympathy to the pupil who is expected to use one of these to find the heat of condensation of steam when his results must be within gun range of 540 calories. Here is a splendid experiment, and a very important one, which has been dropped from almost all physics laboratory courses because of boiler failure. To call the half-condensed vapor which is wafted out of the spout of one of these thin-walled toys steam, is a misuse of the word.

The answer, as many laboratory instructors have found, is a pressure cooker. It will produce all the steam an entire class can use at pressures up to 45 pounds per square inch and is entirely safe. A good pressure cooker in the ten or twelve quart size can be bought for ten dollars or less. To show the effect of pressure on the boiling point of water it is ideal. Using this boiler, fitted with a delivery tube of heavy pressure tubing, the pupil can find the heat of condensation of steam within 2% error every trial.

As you may have suspected, the essence of many of these experiments, presented in the manner I have described, is dramatization. Unscientific, would you say? Not at all. At least, Galileo would not think so. We have reason to believe that Galileo was quite a good showman. The curious thing is that just as much interest would be shown by people now in watching a large and a small stone drop together, side by side, when released from a great height, as was evinced in Galileo's famous experiment long ago from the leaning tower of Pisa. I have found that there is real doubt in the minds of many bright pupils if the stones will actually reach the ground in the same time. No experiment is more easily done. It involves taking the class outside the building but that is no obstacle. You should have little trouble finding a sheer drop of 100 feet or more. If you are able to do this experiment with your class without having it written up in the newspapers as a front-page item, it

will be unusual. It is sensational and at the same time highly instructive.

The dullest experiment in high school physics is that on the laws of the pendulum. The reason is that we commonly use thread and a one-inch steel ball for the pendulum. We can get good results with it too from a mathematical standpoint, but after all it isn't much of a pendulum. Here is another good chance to take your class outdoors for an inquiry into one of nature's rather close secrets. For the pendulum bob, borrow the 12 pound shot from the gymnasium. Suspend it from a tree or some firm support with picture wire. Try to make your longest pendulum at least 25 feet. You can make of this a really impressive and valuable experiment, the more so for its being done outdoors.

The writer realizes that this method of arousing new interest in laboratory physics is not really a classroom method except in the general principle that care should be taken to make each experiment the impressive spectacle that it really is. It is our belief that these natural laws are of absorbing interest to intelligent pupils when clearly and impressively presented.

Our laboratory routine is that which is commonly followed. The pupils work in groups of four or five. Each group has several experiments assigned to it which are to be worked up in finished form and presented before the entire class in demonstration. The historical background of each experiment is studied by the group which demonstrates it. The most interesting parts of this background are given as a preliminary to the experiment.

It is always worth while to make sure that the first experiment of the semester is a good piece of work before the class sees it, because it sets the standard for the entire semester. All the groups later perform separately the experiments which they have seen demonstrated. The data which they record in their notebooks is that which they themselves take.

Always, to be sure, the proof of the pudding is in the eating. Unless the writer is deceived, and he doesn't believe he is, high school pupils like physics when it is presented in this manner. Better still, tests show they understand it.

If there ever was a cause, if ever there can be a cause, worthy to be upheld by all of toil or sacrifice that the human heart can endure, it is the cause of education.—HORACE MANN.

HOW TO KEEP FORTY BUSY*

By Henry P. Harley

Fairmont Junior High School, Cleveland, Ohio

Educational literature abounds in suggestions for making the work of the classroom effective and inspiring. A science teacher of all others ought to be ready and willing to experiment with some of the theories that seem worthy of trial. The most discouraging factor perhaps is the reprehensible load that has been placed on the shoulders of the teacher during the last several years. But the teacher for the sake of his own professional growth cannot afford to become an automaton following schedules, bulletins, and syllabi like the vibrations of a rubber stamp, and make no effort to do some creative work that will bring an alluring freshness to materials and methods in the dynamic subject of science.

The alert science teacher, therefore, as he surveys the field of educational literature becomes most eager to put some of the new ideas into practice even though he is working in a conventional school system. He recognizes with embarrassment the serious limitations of mass instruction. He would like to take his place by the side of the individual student and there encourage him in his successes, guide him around pitfalls, and assist him in remaking and extending his experience.

Another idea that is persisting in the thinking of educators is integration of subject fields and the processes making for integrity in children. The science teacher also hears much concerning progress toward accepted goals of education. Some of these goals are utilitarian, others are related to factors that are designed to function as enrichment toward a broader understanding, appreciation, and enjoyment of life. He is eager to have his subject take its place by the side of others in the curriculum in this onward march toward the fulfilment of noble ideals.

With these high aspirations the alert science teacher launches out. The first jolt puzzles him considerably. Many beautiful theories work smoothly in university high schools, other private institutions, and wealthy suburbs where pupils are highly selected and highly privileged. When his own class comes before

him he stands for forty minutes "in loco parentis" as the instructor of forty or forty-five adolescent children. Some of them are handicapped by language difficulties; some are growing up in an atmosphere of domestic discord; some are stunted by other social limitations.

The effective science teacher, however, will not permit these discouraging factors to dim his vision of the goals of education or dampen his enthusiasm to experiment with some of the new suggestions that come from many sources. But how can he keep forty busy as he strays away from the use of the automatic tools and methods of mass instruction?

Obviously any attempt at an oral question and answer method permits on the average, after time is taken out for announcements and adequate assignments a mere fraction of a minute per pupil. Work books and printed guide sheets are effective in keeping all pupils in some kind of activity. But unless watchful care is exercised these materials degenerate into "cold storage" products and lack dynamic appeal in the solution of fresh problems that should arise from day to day out of the children's experience. Moreover the police duty of the teacher to prevent students from copying answers may become as prodigious as the effort required to assume the role of custodian of these supplies between class periods.

INDIVIDUAL INSTRUCTION

Perhaps the problem that the teacher will desire to solve first in his new efforts will be to plan some methods to keep the rest of the forty busy while he gives one of them some individual help without resorting to "cold storage" materials. The following suggestion has been found feasible. A few thought-inspiring questions or activity assignments are written on the blackboard or projected on a screen. All pupils, after announcements and general assignments have been made concerning work in the future, begin to write their answers on paper or perform the activities indicated. As an example suppose the problem under discussion was, "How do lighting fixtures assist in making life in the home more efficient and pleasant?" The question might be asked something similar to the following:

1. How should illumination in the living room differ from that in the study, dining room, or kitchen?
2. What type of lighting do we have in this classroom?
3. What type of lighting would you suggest for each room in your own home?

> 4. List and describe in the department of "Facts and Principles" of your notebook the general types of lighting fixtures.

The pupils proceed to answer these questions. The teacher passes around the room and gives assistance where needed, keeping in mind those who have language difficulties, poor working habits, those who are underprivileged, and those who need help in how to study. The brighter pupils are given opportunity to go more extensively and intensively into the problem at hand. If further study is desirable or necessary students refer to good textbooks supplemented by books and pamphlets from the school or classroom library.

After this work has progressed for fifteen or twenty minutes, responses are called for from several pupils to each question or activity. A class discussion may develop or a previously assigned reference on a particular phase of the problem may be reported by a pupil or committee. At this time, too, attention may be called to certain pictures on the bulletin board or to photographs relating to the problem; to a laboratory demonstration illustrating intensity and shades of illumination or illustrating the three types of lighting fixtures. In some cases motion pictures and slides may be available to illustrate and otherwise enrich the topic under study.

Should a problem involve activities too extensive for one class period, the unfinished questions and activity instructions can be copied by the pupils in the department of "Assignments" of their notebook. This unfinished work could then be performed at some other study period either at the next session of the class or as outside preparation. For the succeeding meeting of the class it is frequently possible to weave into the leading questions to be answered some relation to the problem studied in the previous meeting that will lay an excellent foundation for a review.

A carefully planned testing program that will reveal something of the progress of the student's ability to organize facts and to see the relation of these facts to our daily life would be a valuable aid to the process of learning and instruction both to children and teacher. While we have in the past perhaps stressed unduly the learning of facts let us not go to the other extreme and ignore that phase of our work entirely. For children of science classes not to have at their command certain basic facts and principles underlying our daily life, comes close to being an "unpardonable sin" laid at the door of somebody.

SOCIAL UNDERSTANDING AND PARTICIPATION

In addition to presenting situations for individual mastery of skills and opportunities to see some of the beauties of nature; one of the accepted goals of education today is to afford children experiences in social understanding and effective participation. A class of forty or forty-five is of itself a fertile field for developing among its members some of the fine social attributes of cooperation, self-control, and harmonious exchange of ideas. But to afford experiences in social participation will stimulate the alert science teacher to do some careful and definite planning.

However, the materials used by the science teacher can be adapted very readily for purposes of experiences in social participation. Projects, round table conferences, socialized recitations, field trips, and clubs if really operated by the children under the guidance of the teacher will furnish abundant situations to develop leadership and harmonious efficient cooperation.

Leadership, however, is frequently mistaken to mean dictation or arbitrary control. Teaching the principles of leadership is a fine art and requires that the teacher himself be a leader. It is to be hoped that science teachers will consider it their professional duty as well as a matter of interest to study and apply in their work the underlying principles of leadership. In general a leader is successful in "influencing people to cooperate toward some goal which they come to find desirable."

Therefore in planning a project or other activity designed for experiences in social understanding and participation, the teacher will spend considerable time in directing attention of his aspiring leaders to the development of desirable goals inherent in a given activity A call for volunteers may bring forward from the group a good percentage of natural born leaders. May we not make the mistake in thinking that the natural born leader is necessarily a student who has on record a high intelligence quotient. Many leaders in our city and township governments are obviously the other kind. The slate of candidates for student council officers chosen carefully by faculty influence in in a school well known to your speaker was badly cracked by an energetic movement led by children of much lower intelligence quotient. The forceful efforts of these natural born leaders nearly swept an entire independent ticket into office.

Let us consider the following as a possible project: To study

how the electromagnet aids in making our daily life more efficient and pleasant. A group of potential leaders may be appointed to serve as an executive board with the teacher as an ex officio member to plan the project. Groups of children may be assigned to carry out the details. One group of pupils having mechanical interests can be assigned to the construction of an electromagnet. Other groups may be designated to describe and demonstrate such devices as electric bells, buzzers, telegraph, telephone, radio, etc. Certain committees may be appointed to make library studies of the historical background of some of these devices, or of the biography of scientists and inventors who made notable contributions. Others may report some recent discoveries or inventions that would have a bearing on the project. The executive board would arrange a schedule for demonstrations and reports, and help solve problems that might arise in the work of any of the groups. The teacher with classes of forty or forty-five will need to exercise good judgment in planning a project to determine the extent of detail that his time will permit.

In directing a project or socialized recitation the teacher, as hinted before, has an excellent field for training his young leaders in the fine art of leadership. Aspiring leaders also need to be warned of certain pitfalls such as; love of power, emotional instability, and the tendency to rationalize doing what is desired and later seek some reason for doing it.

Other members of the group not designated especially as leaders must not be overlooked. Good detail workers in daily life will always be necessary and appreciated They should be warned against such pitfalls as becoming "yesmen" and "rubber stamps"; against the obsessive fear of insecurity, a persecution complex, or inferiority feelings.

Any science teacher knows that a class of forty is not an ideal situation. To give them the advantages of modern methods will in some cases require heroic spirit and efforts, but who would be satisfied when dealing with children to force them through a mill of mass instruction with "cold storage" materials when it is possible to do something in the way of individual help with materials kept fresh and meaningful, and to press toward the goal of mastery of the skills, and appreciation of the beautiful in nature, and social understanding with effective participation.

PROBLEM DEPARTMENT

Conducted by G. H. Jamison

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution as on the following pages.

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1496. *Daniel Finkel, N. Y. C.*

1498. *Daniel Finkel, Hugo Brandt, B. Rutgers, New Brunswick.*

1502. *Proposed by Isadore Chertoff.*

If $a+b+c=0$, prove that

$$\left(\frac{b-c}{a}+\frac{c-a}{b}+\frac{a-b}{c}\right)\left(\frac{a}{b-c}+\frac{b}{c-a}+\frac{c}{a-b}\right)=9$$

First solution by Proposer.

Call first factor P and second factor Q.
Let

1. $\quad \dfrac{b}{a}=k.$ Then $\dfrac{b+a}{a}=-\dfrac{c}{a}=k+1$, since $a+b=-c$

2. $\quad -\dfrac{c}{a}=k+1.$

Since $\quad \dfrac{a}{b}=\dfrac{1}{k}$ from (1), $\dfrac{b}{a+b}=\dfrac{k}{k+1}$ or

3. $\quad -\dfrac{b}{c}=\dfrac{k}{k+1}.$

4. Now adding 1 and 2 $\quad \dfrac{b-c}{a}=2k+1.$

987

Adding reciprocals of 1 and 3 and multiplying by -1,

5. $$\frac{c-a}{b}=\frac{k+2}{k}.$$

In like manner from 2 and 3

6. $$\frac{a-b}{c}=\frac{k-1}{k+1}.$$

From 4, 5 and 6, and factoring numberator

$$P=\frac{(k-1)(2k+1)(k+2)}{k(k+1)}.$$

Using reciprocals, of 4, 5, 6,

$$Q=\frac{9k(k+1)}{(2k+1)(k+2)(k-1)}$$

$$\therefore\ P\cdot Q=9.$$

Second Solution by Hyman Marcus, New York.

$$P\cdot Q=\left(\frac{bc(b-c)+ac(c-a)+ab(a-b)}{abc}\right)$$

$$\left(\frac{a(c-a)(a-b)+b(b-c)(a-b)+c(b-c)(c-a)}{(b-c)(c-a)(a-b)}\right).$$

The numerator of the left hand parenthesis is cyclo symmetric and can be factored into $[-(a-b)(b-c)(c-a)]$. Using this expression, and substituting $c=-a-b$ in the numerator of the right hand parenthesis we have the original expression equal to

$$\frac{-(a-b)(b-c)(c-a)}{abc}\cdot\frac{9a^2b+9ab^2}{(b-c)(c-a)(a-b)}$$

$$=\frac{-(a-b)(b-c)(c-a)}{ab(-a-b)}\cdot\frac{9ab(a+b)}{(a-b)(b-c)(c-a)}$$

$$=9.$$

Solutions were also offered by Daniel Finkel, New York, Julius Freilich, Brooklyn, Hugo Brandt, Chicago, Allin W. Jackson, Kamloops, B.C., A. R. Haynes, Bert Fowler, J. Byers King, Corsica, Pa.

1503. *Proposed by Isadore Chertoff.*

The sides of a $\triangle$ are in *A. P.* If a and c are the smallest and greatest sides, respectively, and r and R are the radii of the inscribed and circumscribed circles, show that $6Rr=ac$.

Solution by A. R. Haynes.

Taking d as the difference between the sides in *A. P.*

$$\left.\begin{array}{l}a=a\\b=a+d\\c=a+2d\end{array}\right\}.\qquad\qquad(1)$$

Then $$s=\tfrac{3}{2}(a+d)=\tfrac{3}{2}b.\qquad\qquad(2)$$

Now
$$R = \frac{abc}{4A}.$$
(3)

where A is the area of the $\triangle$, and

$$A = rs, \text{ or } r = \frac{A}{s}.$$
(4)

Then
$$6Rr = 6\frac{abc}{4A} \cdot \frac{A}{s} = \tfrac{3}{2}\frac{abc}{s}.$$
(5)

Sub. (2) in (5),

$$6RF = \frac{\tfrac{3}{2}abc}{\tfrac{3}{2}b} = ac.$$

Solutions were also offered by Kenneth P. Carlson, Brule, Nebraska, W. E. Buker, Pittsburgh, David L. MacKay, New York, J. Slavin, Brooklyn, N. Y., Julius Freilich, Brooklyn, Hyman Marcus, Hugo Brandt, Chicago, Allin W. Jackson, Kamloops, B.C., D. F. Wallace, Minnesota, David Rappaport, Chicago, Bert Fowler, and H. R. Mutch, Glen Rock, Pennsylvania.

1504. *Proposed by James A. Lemon, Eaton, Ohio.*

A ladder 12 feet is placed on a horizontal walk so that it leans against a vertical wall. The distance from the foot of the ladder to the wall is adjusted so that it rests along the face of a cubical box, edge 4 feet. If one edge of the box is on the walk and the other edge against the wall, what is the shortest distance possible between the foot of the ladder and the wall?

Solution by Bert Fowler, Centralia, Illinois.

Triangle ABC is the triangle formed by the ladder, sidewalk, and wall. AB is the walk, AC is the wall, BC is the ladder. $DEGF$ is a cross section of the cube.
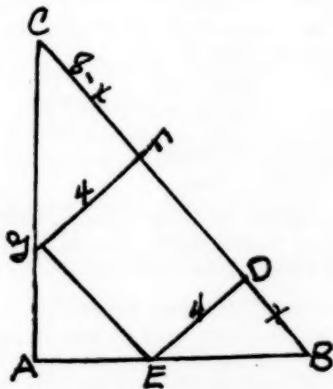
1. Triangle CFG is similar to $\triangle BDE$.
2. Let $BD = x$, then $CF = 8 - x$. Thus in $\triangle CFG$ and $\triangle BDE$

$$\frac{x}{4} = \frac{4}{8-x}, \text{ or } 8x - x^2 = 16, \text{ and } x^2 - 8x + 16 = 0.$$

Then $x-4=0$ and $x=4$. Also $8-x=4$ so $\triangle$ ABC is an isosceles rt. $\triangle$ because $\angle$ B and $C=45°$. Hence

$$AB=\frac{12\sqrt{2}}{2}=6\sqrt{2}=8.484.$$

Solutions were also offered by Julius Freilich, Brooklyn, N. Y., W. R. Smith, Chicago, H. R. Mutch, Glen Rock, Pa., Daniel Finkel, New York City, Charles W. Trigg, Los Angeles, A. R. Haynes, W. E. Buker, Pittsburgh, Pa., J. Byers King, Corsica, Pa., D. L. MacKay, New York City, and Hyman Marcus, New York City.

1505. *Proposed by M. C. Bergen.*

One hundred people attend a picnic. The men pay 5¢ for admission, the women pay 2¢ and the children get in at ten for a penny. The total receipts were $1.00. How many men, how many women, and how many children were at the picnic?

Solution by J. Byers King, Corsica, Pa.

Let $M=$ the number of men at 5¢ each
$\quad W=$ the number of women at 2¢ each
$\quad C=$ the number of children at 10 for 1¢

(1) $\hspace{4cm} M+W+C=100.$

(2) $\hspace{4cm} 5M+2W+\dfrac{C}{10}=100.$

(3) Eliminating W $\hspace{3cm} 3M-\dfrac{19C}{10}=-100.$

(4) Clearing of fractions and solving for C

$$C=\frac{1000+30M}{19}.$$

Since the total receipts were only $1.00 M must be <20 and C must be a multiple of 10. Therefore when $M=11$

$$C=\frac{1000+330}{19}=70 \text{ Children}$$

$$W=19 \text{ Women}$$

$$M=11 \text{ Men.}$$

Solutions were also offered by Hugo Brandt, Chicago, Julius Freilich, Brooklyn, H. M. Zerbe, Wilkes-Barre, Pa., A. R. Haynes, Bert Fowler, Centralia, Ill., Daniel Finkel, New York and M. C. Bergen.

1506. *Proposed by Charles P. Louthan, Columbus.*

A ladder 80 feet in length stands with its base in the middle of the street and when leaned up against the buildings on either side it will reach to a certain height; but a 90 foot ladder with its base in the same place will reach on the buildings 20 feet higher. Find the width of the street.

Solution by David Rappaport, Chicago, Ill.

Using the Pythagorean theorem, we get

1. $x^2+(y+20)^2=90^2$
2. $\hspace{1cm} x^2+y^2=80^2.$

Solving these two equations simultaneously, we get

$$y = 32.5$$
$$x = 73.1.$$

The width of the street equals $2x$ or 146.2 feet.

Solutions were also offered by Daniel Finkel, New York, Julius H. Hlavaty, New York City, John R. Whyte, Toronto, Canada, Bert Fowler, Centralia, Ill., A. R. Haynes, W. E. Buker, Pittsburgh, Pa., H. M. Zerbe, Wilkes-Barre, Pa., J. Byers King, Corsica, Pa., D. L. MacKay, New York, Julius Freilich, Brooklyn, Betty Barrett, Chicago, Hyman Marcus, New York, and E. A. Bababunmi, Monrovia, Liberia, Africa.

1507. *Proposed by Charles P. Louthan, Columbus.*

Find the equation of a line through the intersection points of the line $x - 2y - 6 = 0$, $2x + 3y + 2 = 0$, and $5x + y + 4 = 0$, $2x - 7y - 6 = 0$ without finding the intersection points of the lines.

Solution by J. Slavin, Brooklyn.

Let the equation of the required line be expressed in the form: $ax + by + 1 = 0$.

If the lines $x - 2y - 6 = 0$, $2x + 3y + 2 = 0$, and $ax + by + 1 = 0$ are collinear the determinant of their coefficients equals zero, from which fact we obtain the relation (1) $2a - 2b + 1 = 0$.

In like manner the lines $5x + y + 4 = 0$, $2x - 7y - 6 = 0$, and $ax + by + 1 = 0$ give us the relation (2) $22a + 38b - 37 = 0$.

From (1) and (2) we obtain $a = 3/10$, $b = \frac{4}{5}$.

Therefore the equation of the required line is

$$\frac{3x}{10} + \frac{4y}{5} + 1 = 0 \text{ or } 3x + 8y + 10 = 0.$$

Other solutions were offered by Julius H. Hlavaty, N. Y. C., Aaron Buchman, Buffalo, A. R. Haynes, Howard R. Harold, Tonkawa, Okla., Julius Freilich, Brooklyn, Hyman Marcus, New York City, H. R. Mutch, Glen Rock, Pa., Deane Branstatter, Vandalia, Mo., and the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

For this issue the Honor Roll appears below:

1502, 1505, 1506. John R. Whyte, Upper Canada College, Toronto, Max Lipshitz, Bayonne (N. J.) H. S.

1505, 1506. E. W. Berry, Corsica (Pa.) H. S.

PROBLEMS FOR SOLUTION

1520. *Proposed by William W. Taylor, Port Arthur, Texas.*

Construct a triangle given the circumradius, the inradius and the ex-radius, relative to the base.

1521. *Proposed by Charles W. Trigg, Cumnock College, Los Angeles.*

What is the smallest two-digit number which, when expressed in another

scale of notation, merely has its digits reversed? What is the smallest three-digit number which behaves similarly?

1522. *Proposed by Charles W. Trigg.*

If the sum of the members of each of two number triads is zero, then the sums of the cubes of the triads are in the same ratio as the products of the members.

1523. *Proposed by Aaron Buchman, Buffalo, N. Y.*

In triangle ABC, construct a line parallel to BC intersecting AB and AC at D and E respectively so that DE is the mean proportional between the sum of AD and AE and the sum of DB and EC.

1524. *Proposed by A. R. Haynes, Tacoma, Washington.*

The points P (13, 10), Q (24, 8), R (29, 23) and S (8, 20) are located on the sides AB, BC, CD and DA, respectively of a square $ABCD$. Find the area of the square and determine the slope of AB.

1525. *Proposed by Cecil B. Read, Wichita, Kansas.*

A is the center of a given circle. If B and C are the centers of any two circles tangent externally, but internally tangent to circle A, show that the perimeter of the triangle ABC is constant.

FLASHLIGHT, WITHOUT BATTERY

A battery-less flashlight, one which lights the way without use of dry cells, is the invention for which a patent has just been granted to William I. Holmes, of University Park, Md. The patent is assigned to the Washington Institute of Technology, Inc., of Washington, D. C.

Current for this unique flashlight is provided by a tiny electric generator which fits inside the casing in place of the usual dry cells. The generator is run by a spring motor that is wound up like an ordinary clock. Winding is accomplished by turning a section of the flashlight handle.

To operate the flashlight, all one does is press the button on the casing. This releases the spring motor which transfers its wound-up energy to the generator through a series of gears.

The spinning generator creates the current which lights the electric bulb. Snapping the button back "brakes" the generator and turns off the light.

The inventor claims that his invention may be simply and inexpensively manufactured. In appearance it looks much like the ordinary flashlight.

TIMBER

Thirty-five million acres of farm land have been turned back to forest since 1930 to bring the total woodland area of the United States to nearly 190,000,000 acres, figures released here by the National Lumber Manufacturers Association indicate.

Depression between 1930 and 1935 was primarily responsible for the change, it was explained. During those years farmers turned submarginal lands back to trees. Farm forest lands are holding their own today, however, because of the intensive soil conservation efforts on the part of the government and the growing realization that timber is also a crop.

SCIENCE QUESTIONS

November, 1937

Conducted by Franklin T. Jones

(Send all communications to Franklin T. Jones, 10109 Wilbur Avenue, S. E. Cleveland, Ohio.)

This department is a forum for discussing Tests, Experiments, Pedagogical Questions, Scientific Happenings. Practical Applications of Scientific Principles, Popular Beliefs and Misapprehensions concerning Scientific Matters, Newspaper Science, Think Problems (mostly scientific), Trick Questions, Borderline Science Questions involving Mathematical Treatment, College Entrance Examination Questions and Problems, Any Problem or Question that will help teachers to make Science Teaching interesting.

The discussion usually takes the Question and Answer Form. Readers, whether teachers and students or outside school walls, are invited to propose Questions or Problems and to answer Problems and Questions proposed by others.

As a Mode of Recognizing Contributors, the Guild of Question Raisers and Answerers (GQRA) has been formed and more than 195 contributors have already been admitted to membership. Classes or individuals, may become members by proposing a question or submitting an answer.

JOIN THE GQRA

QUIZ OF THE MONTH—NOVEMBER, 1937

808. In the Interests of Safety a prominent automobile insurance company distributes the following—

Quiz of the Month will be awarded for the best 10 line answer to the heading.

CAN YOU STOP IN TIME?

It takes time to size up traffic and decide to put on the brakes, and still longer to move the foot to the brake pedal. (Average time is $\frac{1}{2}$ second under ideal conditions before brakes start taking effect.) The additional distance required to stop depends on the speed, the condition of brakes and tires, and the road surface.

The stopping distances below are based on ideal conditions.

MILES PER HOUR	TOTAL STOPPING DISTANCE	
	(Car Lengths)	(Yards)
20	2	12
40	7	36
60	14	75

THINKING DISTANCE (Before Brakes are Applied)   BRAKING DISTANCE (While Using Brakes)

On the road your thinking time and braking distance will vary, so that the Total Stopping Distance may be considerably greater than these minimum distances.

Stopping Distance INCREASES Considerably

As Speed Increases So

Be Sure You Can Stop In The Clear Space Ahead.

THE HINDENBURG DISASTER

Since the Board of Inquiry has now settled upon the cause of this disaster, it seems proper to repeat question 802.

802. *From the Newspapers*

Why did not the Hindenburg use helium gas and thus avoid this terrible disaster?

How much hydrogen gas did the Hindenburg carry?

How much did the ship weigh?

What pay load could it carry?

(Please send some pupils to the Library and get this interesting information. Ed.)

WATER POWER HELPED BUILD PYRAMIDS

The historians and classicists have vigorously debated how the immense stones which were laid up in the Pyramids of Egypt were handled.

809. *Edward J. Kunkel, Supervisor of Adult Education in Columbiana County, Ohio, is reported to have said:*

"Water power was used to lift into place the massive stones of the Great Pyramid."

If, as he is reported as saying, the shafts and chambers of the interior constitute a great water pump, why could the workmen handle heavier stone in water than otherwise? Could stones be "locked up" the Pyramids?

COLLEGE ENTRANCE EXAMINATIONS

Questions numbered 810, 811, and 812 are proposed. Satisfactory answer will entitle you to membership in the GQRA.

PHYSICS—ELEMENTARY*

Wednesday, June 23, 1937   2 p.m. Three hours

Answer ten questions as indicated below.

State the units in which each answer is expressed.

No credit will be given for problems on this paper unless the methods of reaching the results are clearly shown.

Number and letter each answer to correspond with the questions selected.

PART I

Answer all questions in this part.

1. A block of silver is counterbalanced in air on an equal-arm balance by a block of aluminum. Which will appear the heavier (*a*) when they are both immersed in water, and (*b*) when the balance and the blocks are placed under a bell jar and the air is exhausted? Explain.

* Copyright, 1937, by the College Entrance Examination Board.

810. —2. A puck weighing 4 ounces is shot forward on ice with a velocity of 60 feet per second, and after 5 seconds has two-thirds its original velocity.
  a) Find the constant retarding force which opposes its motion.
  b) Find the coefficient of friction between puck and ice.
  c) How far will the puck travel before coming to rest?

811. —3. A boy has a 2-pound fish pole 10 feet long, the center of gravity of which is 3.5 feet from the thick end. He finds the weight of his string of fish by hanging them from the thick end of the pole and then balancing the pole on a fence rail. He finds that it balances at a point 15 inches from the end. How many pounds of fish has he?

  4. *a*) How much alcohol (specific heat =0.6) at 20°C. would have to be poured into a calorimeter cup containing 5 grams of ice at 0°C in order just to melt the ice completely?
  b) Would data concerning the cup make possible a more accurate calculation?
  If so, what data, and why?

  5. *a*) State the relation which exists between the pressure and temperature of a gas.
  b) Explain, from the point of view of the behavior of the molecules, why a gas when heated exerts a greater pressure on the confining vessel?
  c) Explain Boyle's law from the same point of view.

  6. *a*) What is the meaning of the designation of a commercial electric light bulb as a "40-watt" bulb?
  b) If a 40-watt bulb and a 60-watt bulb are used in parallel on a 120-volt source, what current is taken by each?
  c) What is the resistance of each?
  d) If these two lights are connected in series to the same source, will the total power consumed be the same as before? Why?
  e) Under these circumstances which bulb will get hotter and why?

  7. A bar magnet is placed in a vertical position, N.-end up, and a metal hoop is held in a horizontal position directly above the upper end of the magnet. The hoop is then dropped over this end of the magnet.
  a) Explain why an induced current occurs in the ring as the latter approaches the N.-pole of the magnet.
  b) State the direction of this current as seen from above the ring.
  c) State the law by which the direction is determined and explain how you applied the law.
  d) How, if at all, is the rate of fall of the hoop affected and why?

  8. *a*) Describe by diagram a simple modern telephone circuit consisting of transmitter at one end and receiver at the other.
  b) Explain in detail, with reasons, how a sound is transmitted by this circuit and reproduced at the receiving end.

  9. *a*) Describe a method by means of which the velocity of light has been determined. State what data or observations are required and how from them the velocity is computed.
  b) If the space between us and the stars were uniformly occupied by medium having optical properties similar to those of water or glass, what difference would be noticed in watching a bright star pass behind the moon?

PART II

Answer one of the following questions.

10. The ratio of the speed of light in air to that in water is about 4:3; the ratio of its speed in air to that in glass is 3:2.

   a) Draw the approximate path of a light beam entering the surface of a pond of water obliquely. Give reasons for the behavior of the light beam.

   b) Draw the approximate path of a light beam traveling from water to glass. Give reasons.

   c) The index of refraction of the human eye lens is only slightly greater than that of glass. Explain why a person swimming under water cannot possibly see distinctly with unaided eye.

812—11. A barometer tube 80 centimeters long, filled with air when the barometer reads 75 centimeters, is thrust open-end downward into a lake until water fills 50 centimeters of the tube.

   a) How many meters below the surface of the lake is the bottom of the tube?

   b) What is the density of the air in the tube under those circumstances, if a liter of air at the surface weighs 1.29 grams?

   c) State two principles or laws involved in answering this problem. Assume that the temperature remains constant. The specific gravity of mercury is 13.6.

Have you answered *ten* questions?

If you have answered more than ten questions, cross out the one in Part II that you do not wish to have count.

Questions numbered 813 and 814 in this examination paper are proposed. Satisfactory answers will entitle you to membership in the GQRA.

BIOLOGY—ELEMENTARY*

Saturday, June 26, 1937   9 a.m. Three hours

Answer eight questions as indicated below.

Number and letter your answers to correspond with the questions selected.

PART I

Answer all questions in Part I.

1. In approximately 250 words describe, without using drawings, what you have observed during your laboratory study of any two of the following:

> tentacle of hydra
> an alga
> side view of an insect
> cross section of a leaf

2. a) Define: (1) osmosis
                (2) diffusion

   b) With these definitions in mind state the materials and the processes involved in the functioning of the following:

(1) root hair
(2) villus
(3) stoma
(4) air-sac of lung

813—3. State three biological measures for the protection of each of the following:
  a) water supply
  b) milk supply

4. a) What general characteristics of structure, function, behavior, and habit have contributed to the success of the insect group?
  b) What special adaptations of the grasshopper or of the bee fit it to its particular environment?

5. Copy the list of terms in Column I into your answer book and after each write the number of the statement from Column II that best describes it.

Column I	Column II
a) associative neuron _____	1. the meeting of parts of the neurons
b) cerebellum _____	2. closing the eyes when a strong light is flashed
c) cerebrum _____	3. transfers stimuli to the inner ear
d) ganglion _____	4. the wilting of a plant
e) medulla _____	5. part of the brain that controls conscious activity
f) medullary (myelin) sheath _____	6. a structural unit which carries impulses between the brain and the spinal cord
g) paralysis _____	7. result of the destruction of cell bodies of motor neurons
h) reflex action _____	8. place where the rate of respiration is controlled
i) synapse _____	9. fatty covering of nerve fibers
j) tropism _____	10. controls co-ordination of muscular movement
	11. turning of a plant in response to a stimulus
	12. portion of the neuron which contains the nucleus
	12. nerve center outside of the central nervous system

PART II

Select three questions from Part II. If more than three are answered, only the first three will receive credit.

6. In a large, carefully drawn, and fully labeled diagram of a cross section of a dicotyledonous stem indicate those structures concerned with:
  a) transverse conduction   d) support
  b) longitudinal conduction   e) protection
  c) growth

7. Make a drawing, at least 4 inches long, of a paramecium. Label and give the function of ten parts.

8. Define briefly each of the following terms:

gamete	maturation
gene	mutation
haploid	dominant
zygote	unit characters
sex-linked	mitosis

814—9. During recent years the Middle Western states have had great dust storms.
   a) What were the probable causes of these?
   b) As a biologist what measures would you advise to prevent their recurrence?

10. Present discussion of the economic value of fishes. Include the following four topics:

   a) importance as a food supply
   b) kinds of food fishes commonest in your state
   c) ways other than the food supply in which fish are important to man
   d) the spawning habits of one of the following:
      (1) the common eel
      (2) the Pacific salmon
      (3) some other commercially important fish

Have you answered *three* questions in Part II?

COUNTER-CLOCKWISE ROTATION

815. *Proposed by Vernon McNeilus (Elected to the GQRA, number 196), Clarion High School, Clarion, Iowa.*

When water is poured down a drain, it naturally and invariably seems to rotate in a counter-clockwise direction.
Is this controlled by some physical law?
An explanation will be appreciated.

LOOKING FORWARD

803. *What are you going to start this fall that is new, or unusual, or more interesting?*
What do pupils think of the science of courses we are giving?
What can "Science Questions" do to be of greater use to a larger number of readers of SCHOOL SCIENCE AND MATHEMATICS?

JOIN THE GQRA

METEORITE

Soviet scientists are hunting for a large meteorite, possibly the largest yet known in the Soviet Union, in the Komarinsk district of White Russia, following the discovery of two fragments, states Tass, Soviet news agency.
   One, weighing 300 kilograms (about 660 pounds) has already been turned over to the Geological Museum of the White Russian Academy of Sciences for study. The other, just found, weighs 16 kilos (about 35 pounds). Both are iron meteorites.

BOOKS RECEIVED

General Biology Study-Book, by Holger H. Van Aller and Dorothy Van Aller, High School, Saratoga Springs, New York. Cloth. Pages xi+149+32. 12×19 cm. 1937. Globe Book Company, 175 Fifth Avenue, New York, N. Y. Price $1.00.

Atomic Artillery, by John Kellock Robertson, Professor of Physics, Queen's University, Kingston, Canada. Cloth. Pages xiv+177. 13×20.5 cm. 1937. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $2.25.

A Hundred Years of Chemistry, by Alexander Findlay, Professor of Chemistry in the University of Aberdeen. Cloth. 352 pages. 13.5×21.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $4.25.

Workbook to Practical Mathematics, by N. J. Lennes. Paper. 160 pages. 21×28 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price 60 cents.

A Laboratory Guide and Workbook to accompany Millikan, Gale, and Coyle's New Elementary Physics, by Burton L. Cushing, Head of the Department of Science, East Boston High School. Paper. Pages vi+241. 18.5×28 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price 76 cents.

Developing a High School Chemistry Course Adapted to the Differentiated Needs of Boys and Girls, by Margery Stewart Gillson, Teachers College, Columbia University Contributions to Education, No. 709. Cloth. Pages vii+95. 15×23 cm. 1937. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.60.

The Mathematics in Certain Elementary Social Studies in Secondary Schools and Colleges, by Eugene W. Hellmich. Teachers College, Columbia University Contributions to Education, No. 706. Cloth. Pages vi+125. 15×23 cm. 1937. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $1.85.

The Machinery of the Body, by Anton J. Carlson and Victor Johnson, The University of Chicago. Cloth. Pages xvii+580. 15.5×23 cm. 1937. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $4.00.

Methods of Quantitative Chemical Analysis, by M. G. Mellon, Professor of Analytical Chemistry, Purdue University. Cloth. Pages ix+456. 14× 21.5 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

Laboratory Manual of General Chemistry, by Harry N. Holmes, Professor of Chemistry in Oberlin College. Fourth Edition. Cloth. Pages viii+299. 20×27 cm. 1937. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.50.

Educational Psychological Personality Tests of 1936, by Oscar K. Buros, Rutgers University. Paper. 141 pages. 15×23 cm. 1937. School of Education, Rutgers University, New Brunswick, New Jersey.

The Advancing Front of Science, by George W. Gray. Cloth. Pages xiii+364. 14×23 cm. 1937. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $3.00.

Intermediate Algebra, by Samuel E. Urner, Ph. D., Los Angeles Junior College and William B. Orange, M. A., Los Angeles Junior College. Cloth. Pages xv+432. 12×18 cm. 1937. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York. N. Y. Price $2.00.

Introduction to College Algebra, by William L. Hart, Ph. D., Professor of Mathematics, University of Minnesota. Cloth. Pages v+246+24. 13×20 cm. 1937. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.84.

The Calculus, by Robert D. Carmichael, Professor of Mathematics, University of Illinois, James H. Weaver, Professor of Mathematics, Ohio State University, and Lincoln Lopaz, Associate Professor of Mathematics, Ohio State University. Cloth. Pages xvi+384. 14×21 cm. 1937. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $3.00.

Laboratory Manual in Chemistry, by Ralph E. Horton, Chairman of the Department of Science, Seward Park High School, New York, N. Y. Cloth. Pages ix+99. 13×21 cm. 1937. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.00.

Biological Laboratory Technique, by H. Bronte Gatenby, Ph. D., Professor of Zoology and Comparative Anatomy, Trinity College, Dublin University. Cloth. Pages vii+130. 13×20 cm. 1937. Chemical Publishing Company of N. Y., 148 Lafayette St., New York, N. Y. Price $3.00.

Workbook in General Science, by Hanor A. Webb, Ph. D., Professor of the Teaching of Chemistry and General Science, George Peabody College for Teachers and Robert O. Beauchamp, M. A., Instructor in Science, The Demonstration School, George Peabody College for Teachers. Paper. Pages vi+312. 20×26 cm. 1937. D. Appleton-Century Company, 35 West 32nd Street, New York, N. Y. Price 88 cents.

PAMPHLETS RECEIVED

Statement of Policies for the Administration of Vocational Education, Revised February 1937. United States Department of the Interior. Pages ix+137. 15×23 cm. Superintendent of Documents, Washington D. C. Price 25 cents.

Mathematical Requirements for the First Courses in College Physics, by Karl Ferdinand Oerlein, Professor of Physics, State Teachers College, Indiana, Pennsylvania. Pages 140. 15×23 cm. 1937. For sale by the Author. Price $1.00.

Cooperative Organization of Iowa Farmers' Creameries, by Frank Robotka and Gordon C. Laughlin. Pages 92. 15×23 cm. 1937. Farm Credit Administration, Washington, D. C.

A Summer Vacation Guide, Nature and Science, by Guide Book Committee, Jennie Hall, Chairman. Pages 36. 14×21 cm. 1937. Minneapolis Public Schools, Minneapolis, Minn.

Auto-Radio Pocket Trouble Shooter "Gadget", by Alfred A. Ghirardi. Radio and Technical Publishing Company, 45 Astor Place, New York, N. Y. Price 50 cents.

Tests in Biology, by Frederick L. Fitzpatrick, Associate Professor of Natural Sciences, Teachers College, Columbia University. Houghton Mifflin Company, 9 Park Street, Boston, Mass. Set of seven tests, 40 cents.

Economic Analysis of Bargaining Problems of Milk Cooperatives, by T. G. Stitts and Wm. C. Welden. Pages 54. 15 ×23 cm. 1937. Farm Credit Administration, Washington D. C.

Bird Calendar, Key and Check List and Tree Calendar, Key and Check List, by Wm. G. Vinal, Massachusetts State College. W. F. Humphrey Press, Inc. Price for each calendar, less than 100, 2 for 5 cents, 100 or more 2 cents each.

Catalog No. 5 of Technical Publications. Chemical Publishing Company of N. Y., 140 Lafayette Street, New York, N. Y. Price 10 cents.

BOOK REVIEWS

The World and Man as Science Sees Them, edited by Forest Ray Moulton. Cloth. Pages xix+533. 15 ×23 cm. 1937. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $3.00.

This book is designed to fill the demand for a textbook for orientation courses in college science and also to appeal to the science reading public. It was written by thirteen eminent scientists all now or formerly members of the faculty of the University of Chicago, and edited by Dr. Forest Ray Moulton, internationally famous teacher, lecturer, investigator and author. The subject matter covers the entire field of physical and biological science, stressing as the title indicates the position of man in the universe. The first section, Astronomy, shows the gradual extension of the horizon from the few bodies of the solar system and the nearer stars to the distant universes revealed only by the most powerful telescopes equipped with spectroscopes of highest resolving power and the most sensitive photographic plates. The section on geology shows the geologic rhythm through cycle after cycle of diastrophism and emergence followed by degradation and monotony, and closes with a prophesy of a long future. Thus each section of the book is woven about a central theme which makes its particular contribution to the development of the general topic suggested by title. A little less than two-fifths of the volume is devoted to the four chapters allotted to the physical sciences and the remainder to the life sciences. Each chapter is a fascinating story, authoritative and up-to-date. Certainly no one can read the book without a great increase in the breadth of his outlook and without being stimulated to increase his knowledge of the world about him. The book will without doubt accomplish this, its chief objective, and the attractive trade edition should have extensive sales.

As a textbook for class use it is not so well adapted. Its eleven chapters are to a large degree separate books. The organization shows a general plan which the authors followed, but with considerable individual liberty; the various branches of science are quite definitely separated from each other. With the exception of a discriminating bibliography at the end of the text, consisting of a short list of books for additional reading on each chapter, the text supplies none of the usual teaching and learning aids considered essential to all textbooks. Division of the educational edition

into subtopics, with skillful use of bold-faced type and italics would add much to its value, convenience and effective use by both instructor and student. Without these rapid reference for intensive study is impossible. The limited number of maps, pictures, and diagrams, and the complete absence of such teaching devices as lists of questions, topics for further study, etc. leave much additional work for the instructor. But even with these omissions its reliability and its inspirational character are sufficient to give it a leading place in the textbook field for orientation classes.

G.W.W.

Plane Trigonometry with Tables, by Harvey Alexander Simmons, Associate Professor of Mathematics, Northwestern University, and Greenville D. Gore, Professor of Mathematics and Chairman of the Departments of Mathematics and Engineering Drawing, Central Y.M.C.A. College of Chicago. Cloth. Pages viii+201+81. 14×22 cm. 1937. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.00.

The essential features of this text that will appeal to both teachers and students are the laconic discussions of theory and an abundance of problems which emphasize mastery of processes and applications of the principles to geometry, mechanics, physics and astronomy. A three-place table of trigonometric functions is embodied in the second chapter, thus giving the student simple and convenient tools while learning. Certain starred sections may be omitted without breaking the continuity. Answers to the problems and an index are included. An eighty-page section supplies tables of squares and square roots, constants and their logarithms, natural logarithms of numbers, five-place logarithms of numbers, logarithms of functions, and four-place values of functions and radians.

G.W.W.

New World of Chemistry, by Bernard Jaffe, Chairman, Department of Physical Sciences, Bushwick High School, New York City; Author of Crucibles; The Lives and Achievements of the Great Chemists, Outposts of Science, Chemical Calculations, etc. Second Edition. Pages xii+366+xxx. 2.9×14.5×20.5 cm. With drawings and photographs by Adrian J. Iorio. Cloth. 1937. Silver Burdett Co. Price $1.80.

This new edition of a "different" type of text has been prepared because of the rapid advance of the science in the two years since the first edition came out. The discussion of atomic structure and the electronic diagrams have had to be modified (one wonders how long it will be before the styles change again!) The author's declared purpose is "to give to the student a clear picture of the basic theories of chemistry accepted today, and to bring up-to-date his knowledge of those applications of chemistry which affect his daily life." The author is eminently successful in his efforts to humanize chemistry teaching. His biographical setting is superior. The illustrations of the text are abundant, well chosen and of excellent merit. Although the book is really "different" from most texts it covers adequately all of the necessary material for "College Board Exams," Regents' Exams and all of the requirements of the "Standard Minimum Outline" of the American Chemical Society's Committee.

F. B. Wade.

Man in a Chemical World, The Service of Chemical Industry, by A. Cressy Morrison, First Edition. Pages xi+292. 3×17×23.5 cm. Striking symbolic frontispiece in colors representing Chemical Industry, upheld by Pure Science, sustaining the Production of Man's Necessities. Other illustrations. Cloth. 1937. Charles Scribner's Sons. Price $3.00.

This remarkable book was written to order for the Chemical Industries Tercentenary Committee after the great national celebration of the completion of three centuries of constructive achievement by the chemical industries of America. It was written for the "man in the street" and has both cultural and utilitarian values. It should disabuse the ordinary citizen of the false impression, too often foisted on the public by unscrupulous or misguided politicians, that our chemical industries are engaged solely in the preparation of high explosives and other war materials. Too few people realize that, in normal times, our greatest manufacturers of explosives are in that business only to the extent of about one per cent of their production and ninety-nine per cent busy in making rayons and almost everything else for the betterment of society.

The American Chemical Society, realizing the need for a better understanding of the constructive work being done for society by our great chemical industry, held, in 1935, its Tercentennial of American Chemical Industry, in New York and this book was thus inspired.

After a brief discussion of some of the raw materials of chemical industry, air, water, salt, sulphur, lime, coal, petroleum and natural gas the author goes on to describe some of the wonderful organic products of chemical industry and the increasing use of cheap agricultural waste materials in the making of useful products. A chapter on "Keeping Well," with its simple explanations of vitamine sources and uses and an account of the essential mineral constituents of foods is followed by one on "Feeding Millions" which deals with the making and use of fertilizers. "Wheels and Wings" treats of the petroleum industry. Other chapters are entitled "All the Comforts of Home," "Security," "The More Abundant Life," etc. This is a book for everyone who would be informed in regard to one of the most likely means of bringing about better conditions for the "ill clad, the ill fed and the ill housed."

F. B. WADE

General Mathematics for Students of Business, by William S. Schlauch, New York University. Cloth. Pages ix+394. 15×23 cm. 1936. F. S. Crofts and Company, 41 Union Square, West, New York, N. Y. Price $1.75.

This book is designed primarily for students of business. However, it differs from a general text in freshman mathematics only in that it offers somewhat more problems which present business situations. The first nine chapters contain material which, for the most part, may be found in an advanced high-school algebra. Thus, for students who have had a good course in algebra this material may be used for reference or for review. In these chapters we find numerous problems which arise in business.

We present a list of the chapter headings beginning with the tenth chapter to indicate the character of the subject matter. The heading of Chapter X is "Mathematics Useful in Finance." It is a treatment of arithmetic and geometric progressions with applications to business situations such as simple interest, compound interest, present value at compound interest, annuities, and present value of an ordinary annuity. The remaining fourteen chapters have, in order, the following headings: Permutations, Combinations, and the Binomial Theorem; Probability; Life Insurance, Life Annuities, and Inheritance Taxes; Trigonometry; Constants, Variables, Functions, Derivatives; Differentiation; Successive Differentiation and Partial Differentiation; Maxima and Minima; Distribution of Errors and Natural Phenomena; Measures of Deviation and Equation of the Normal Frequency Curve; Index Numbers; Curve Fitting and Regression Lines; Closeness of Estimate and Correlation; Correlation. In the appendix we find a brief treatment of determinants and thirteen tables.

The author presents outlines indicating the material that might be selected for a two-hour, three-hour, or a four-hour course for a period of 30 weeks.

A student who has mastered the material in this text has a good foundation for the specialized courses in mathematics of investment, finance, insurance, business calculations, statistics, and budgeting.

J. M. KINNEY

First Year College Mathematics, by Volney Wells, Ph. D., Associate Professor of Mathematics in Williams College. Cloth. 16×23.5 cm. 1937. Part I, pp vi+133. Part II, pp. ix+276. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York.

In the two books under review the author has collected material sufficient for a course of one year. Part I deals exclusively with trigonometry. The content of the course differs but little from that of the standard trigonometries. The definitions of the functions are cast in the general form. We find numerous problems which are conveniently graded in groups A, B, C, and D. There are no tables excepting a three-place table of the natural functions.

Part II is a book which deals with college algebra, analytic geometry and elementary calculus. The organization of the course is indicated by the following chapter headings: Cartesian Coordinates, Equations and Loci, Straight Lines, Functions and their Graphs, Solution of nth degree Equations, Rate of Change, Differentiation of Polynomials, Parabolas, Circles, Differentiation of Algebraic Functions, Central Conics, Curve Tracing, Integration, Parametric Equations, Transformation of Coordinates, Polar Coordinates, and Complex Numbers.

We find the calculus, after its introduction in Chapter VI, is used quite consistently in the chapters on the parabola, central conics, curve tracing, and parametric equations. In this book, as in the first, we find numerous problems which are arranged as to difficulty in groups A, B, C, and D.

J. M. KINNEY

Analytic Geometry and Calculus, by Max Morris, Associate Professor of Mathematics, and Orley E. Brown, Assistant Professor of Mathematics, both of Case School of Applied Science. Cloth. x+507 pages. 16×23.5 cm. 1937. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $3.75.

The authors take the position that at the present time a first course in analytic geometry is to a large extent a preparation for the calculus. It is so presented in this volume. Instead of material divided into fifteen to twenty chapters and covering 300 to 400 pages, we find here six chapters covering 139 pages. The introductory chapter includes such topics as Cartesian and polar coordinates, inclination and slope, and translation and rotation of axes. The following chapters deal, in order, with Graphs and Loci, The Straight Line, Equations of the Second Degree, Special Plane Curves, and Solid Analytic Geometry.

The remainder of the volume is devoted to the calculus. The material is practically the same as that found in the standard texts. The authors believe the student should not shirk the task of reading a somewhat rigorous proof. We thus find the use of deltas and epsilons and such terms as neighborhood and deleted. Throughout the calculus we find a liberal supply of exercises and applied problems.

J. M. KINNEY

College Algebra, by Claude Irwin Palmer, Late Professor of Mathematics and Dean of Students, Armour Institute of Technology, and William Lee Miser, Professor of Mathematics, Vanderbilt University. Second Edition. Cloth. Pages xi+467. 12×18.5 cm. 1937. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.50.

This book is a standard text in college algebra. It has been prepared to meet the needs of students in classes in which there are wide spreads of ability and mathematical preparation. In this second edition most of the exercises and problems of the first edition have been replaced, illustrative examples have been added, and some of the text has been rewritten. There is an abundance of exercises and problems. Of the latter a large number are problems arising in the sciences, engineering, business, and other activities.

J. M. KINNEY

Tricks, Toys, and Tim. A Book of Model-Making and Magic, by Kreigh Collins. Cloth. Pages xii+238. 13×19 cm. 1937. D. Appleton-Century Company. New York. Price $2.00.

A discipline problem in the home and in the school is frequently a result of lack of directed activity. Here is an intriguing little volume which will help to start a youngster on an instructive hobby.

The first section describes a number of things a boy can make. The central portion describes how the magician works and includes full directions for making the necessary equipment. In section three the reader is transported into the past and learns how to make devices to escape various snarls.

The book makes a fine gift for a youngster up to 12.

C. RADIUS

How To Make Electric Toys, by Raymond F. Yates. Cloth. Pages xvi+199. 13×19 cm. 1937. D. Appleton-Century Company. New York. Price $2.00.

Many great workers in electricity can trace their association with this most useful force to boyhood days in an attic or cellar. Far from being a matter of curiosity, this little volume is really a primer in electricity. Through the construction and operation of many small inexpensive devices the boy is introduced to many of the fundamental properties of electric currents. Diagrams and photographs accompany each project.

Teachers of elementary and general science will find this book helpful in suggesting outside activities.

C. RADIUS

General Mathematics, by Harris Crandall, Superintendent of Schools, Saratoga Springs, New York, and F. Eugene Seymour, Supervisor of Mathematics, New York State Department of Education, Albany, New York. Cloth. Pages v+389. 13×21 cm. 1937. D. C. Heath and Company, 285 Columbus Ave. Boston, Mass. Price $1.28.

Every mathematics teacher is aware of the paradox that now exists in their field. Required mathematics is steadily decreasing while the application of mathematics to modern life is constantly increasing. The authors of this text are meeting the problem with a socialized mathematics, one that will answer the common sense needs of the home, shop or office. However, the text is neither shop nor business mathematics. It does lay a foundation for both.

The three fields of mathematics have been drawn upon freely. Since

the book is written for the last year in Junior High or the first year in Senior High School, the authors are not concerned with the teaching of arithmetic. The fundamental facts of arithmetic are reviewed by diagnostic test and drills. Algebra is carried through simple fractional equations. Most of the geometry is of the intuitive type. Unit VI on Everyday Social Problems is exceptionally well written to arouse interest in problems that the student will meet in later years. Each unit is terminated with a summary and tests of various types.

There is a fair distribution of diagrams. The grotesque animated diagram should have been omitted.

C. RADIUS

Laboratory Practice of Organic Chemistry, by G. Ross Robertson, Associate Professor of Organic Chemistry in the University of California at Los Angeles. Cloth. xii+326. 15×22 cm. 1937. The Macmillan Co., New York. Price $2.25.

"The main feature of this volume is an unusually extensive, but informal treatment of the principles underlying laboratory manipulations in organic chemistry. Part I consists largely of this theoretical material. Part II deals with synthetic experiments and a few examples of elementary qualitative and quantitative analysis." 140 pages are devoted to a discussion of physical and chemical principles.

Directions are given for an adequate number of syntheses to permit a selection by the instructor. Topics are numbered and cross references are provided. The appendix includes numerical data, selection of experiments, special materials for the experiments to aid the purchasing of supplies. Indexed. Well worth thoughtful consideration.

DRULEY PARKER

Organic Chemistry Guide, by E. Wertheim, Professor of Organic Chemistry in the University of Arkansas. Flexible paper. xii+524. 21.5×28 cm. 1937. P. Blakiston's Son and Company, Philadelphia.

Ample experimental material for a year's work in elementary organic chemistry. Numerous test tube experiments are included under the head of "properties." The syntheses avoid the use of anything but the most simple assemblies. Removable report sheets are provided. Each experiment has a time table which represents the average time taken by the student on each experiment in the author's laboratory. Appendix. Index.

DRULEY PARKER

Arithmetic for Teacher-Training Classes, E. H. Taylor, Head of the Department of Mathematics, Eastern Illinois State Teachers College. Revised Edition. Cloth. Pages vii+432. 12.5×19 cm. Henry Holt and Company, 257 Fourth Avenue, New York, N. Y. Price $1.70.

In the revised edition of this popular text the general content has been retained. The major changes include the extension of certain topics and additions to the discussions on methods of teaching arithmetic. Of particular value to the student and teacher are the results of recent studies and research which are given together with references to the sources. Such topics as problem solving, causes and treatment of errors, skills in fundamental operations, value of rationalization, aims and methods of drill, and the algebra and geometry used in the seventh and eighth grades have been elaborated and discussed in light of recent educational trends. These desirable additions should give the book even greater success.

L. C. WARNER

Mammalian Anatomy with Special Reference to the Cat, by Alvin Davison, Ex-Fellow of Princeton University; Professor of Biology in Lafayette College and revised by Frank A. Stromsten, Associate Professor of Animal Biology, State University of Iowa. Sixth Edition. Cloth. Pages xiv+328. 14×21.5 cm. 1937. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $3.00.

For courses in vertebrate zoology the use of Davison's *Mammalian Anatomy* has long been regarded as standard. The fact that six editions have been issued may be taken as an indication of the usefulness of this work to the teachers of advanced biology. While of value primarily as a help in laboratory work, the descriptive and text material merits the attention of students majoring in Physiology, Physical Education, and Psychology. The general plan of the book is little changed. Each chapter, covering some major system of the mammalian body, is concluded with a number of questions and suggested studies. Some parts have been considerably expanded and additional illustrations included. A ten-page glossary with derivations adds much to the practical value of the book. A section dealing with the preparation of laboratory material will appeal to those who must preserve their own specimens for study.

J. F. Schuett

Our World of Living Things, by Elwood D. Heiss, Head of the Science Department, State Teachers College, East Stroudsburg, Pennsylvania; Ellsworth S. Obourn, Head of the Science Department, John Burroughs School, Clayton, Missouri; and J. Gordon Manzer, Teacher of Science, High School, Tenafly, New Jersey. Cloth. Pages vi+274. 21×27.5 cm. 1936. Webster Publishing Company, 1808 Washington Avenue, St. Louis, Mo. Price $1.08.

Our World of Living Things is a one year's course in high school biology. The knowledge content is organized around the important principles in biology on the unit-topic-problem basis. Each unit is introduced by a thought-provoking preview. The preview is followed by problems and questions. Then a series of topics are given. The topics include subject matter, experiments, and various types of exercises. A summary of important ideas and references is included with each topic. Objective tests are also provided.

This book is large and printed with two columns on each page. It is well illustrated with diagrams and photographs. The language is well adapted for pupils of high school age.

The authors have fused the three parts of biology in an excellent manner. Biology is presented as the relationship between living things and not as three separate courses in botany, zoology, and physiology.

Our World of Living Things is easily adapted to any method of teaching. It is flexible in its plan and organization. A list of books to read, supplementary activities, problems to solve, etc., help materially in providing for individual differences.

Ira C. Davis

Modern Science Problems, A Textbook in General Science, by Ellsworth S. Obourn, head of the Science Department, John Burroughs School, Clayton, Missouri, and Elwood D. Heiss, Head of the Science Department, State Teachers College, East Stroudsburg, Pennsylvania. Cloth. Pages v+322. 21×27.5 cm. 1936. Webster Publishing Company, 1808 Washington Avenue, St. Louis, Mo. Price $1.08.

One of the reasons given for the large size of this book was that it made possible the use of larger illustrations than usually found in textbooks.

Despite the size of the pages the illustrations use, for the most part, only one column. Very few two column cuts are found.

Two other reasons for the size and make up of the book are that the shorter lines are better suited to the eye span of young students, and that the type of binding made possible because of the size, prolongs the life of the book by at least two years.

The book is divided into thirteen units concerned with the following topics and arranged in the following order: (1) air, (2) climate, (3) water, (4) food, (5) light, (6) heat, (7) machines, (8) astronomy, (9) geology, (10) biology, (11) electricity, (12) communication, (13) transportation.

Emphasis has been placed on some of the newer aspects of home and consumer science.

Unit III, which deals with the relation between water supply and the welfare of the community, is handled in a different way than usual. The material is much more extensive and the subject is treated more completely than in previous science texts.

Each unit is preceded by some statements of known facts about the subject which sums up what the student knows about it. There are suggested problems and questions followed by suggestions and helps for study.

The experiments or demonstrations which will help answer the problem questions are performed first, then the student is asked to read the text material which should provide him with a well rounded knowledge of the topic. There are many references for further study following each topic and self mastery tests enable the pupil to check his mastery of the topic.

The simple equipment necessary for the experiments is the type found in any community and should be available in all schools.

There is a teachers' manual to accompany the text which contains unit tests covering each unit of work.

H. G. McMullen

Higher Algebra, by S. Barnard, Formerly Assistant Master at Rugby School, Late Fellow and Lecturer at Emmanuel College, Cambridge, and J. M. Child, Formerly Lecturer in Mathematics in the University of Manchester, Late Head of Mathematical Department Technical College, Derby, Formerly Scholar at Jesus College, Cambridge. Cloth. Pages XIV + 585. 13.5 × 21.5 cm. 1936. Macmillan and Company, London. Price $6.00.

The book is a treatise on the fundamental concepts and processes of Algebra. It includes the materials ordinarily treated in College Algebra and Theory of Equations, but the point of view is that of advanced mathematics. The book is not suited as a text in Algebra in an American college, but is an excellent reference to be used by teachers of mathematics and students specializing in the subject.

J. S. Georges

Mathematics of Finance, by D. H. Mackenzie, Assistant Professor of Accounting and Management, University of Washington. Cloth. Pages IX + 313. 1937. Including Compound Interest and Annuity Tables, by Frederick C. Kent, Associate Professor of Mathematics, Oregon State College, and Maude E. Kent. Pages VIII + 214. 15 × 23 cm. 1936. McGraw-Hill Book Company, Inc., New York. Price $3.75.

After reviewing elementary Algebra and logarithmic computation, the book takes up in detail the following topics: Simple and Compound Interest; Annuities; Amortization; Sinking Funds; Bonds; Building and Loan Associations; Valuation; and Life Insurance. The second part includes the Compound Interest Tables; Annuity Tables; Logarithmic Tables; and Table of Mortality.

The Author develops each topic by means of examples and illustrations. Special cases are classified and analyzed separately. This method of treatment is intended to enable the student to understand business problems in their simplified form.

The typography and format of the book are excellent.

J. S. GEORGES

Mathematical Snack Bar by Norman Alliston. Cloth. Pages VII+155. 13.5×21.5 cm. 1936. W. Heffer and Sons Ltd., Cambridge, England. Distributed in America by Chemical Publishing Company, 148 Lafayette Street, New York, N. Y. Price $3.00.

This unusual book is a collection of notes dealing with a variety of mathematical problems. It contains original results in Diophantine Analysis, Theory of Numbers, Geometry, and Trigonometry. The topics investigated are: Triangles; Quartered Parallelograms; Cylic and Circumcyclic Quadrilaterals; Tangencies; Ranging; Pyramids; Polygons; Proof; Bequadratic Expressions; Residue; Goldbach's Theorem; Primes; Heronian Triangles; Fermat Problems; and "Alternatives" in Diphantus.

Students of mathematics interested in research will delight to ponder over this original and "home made" treatment of classical problems presented in an ingenious style.

J. S. GEORGES

Projective Geometry, by Boyd Crumrine Patterson, Professor of Mathematics, Hamilton College. Cloth. Pages XIII+276. 14×21.5 cm. 1937. John Wiley and Sons, Inc., New York, N. Y. Price $3.50.

The purpose of the book is explained quite well by the following statement in the preface: "Thus, the underlying principle has been to present as complete a discussion on the subject matter as seemed consistent with an introductory course." The author has followed that principle consistently and has indeed presented an adequate treatment of the elementary concepts of Projective Geometry.

The method of treatment is that of synthetic geometry as distinguished from analytic geometry. While the emphasis throughout is on the projective properties, yet metric properties are also considered as specializations of the projective concepts.

The following Table of Contents reveals the scope of the topics considered: Introductory Concepts; The Metric Properties; The Principle of Duality; Perspectivity; Harmonic Sets; Projectively Related Primitive Forms; Conics and Cones; Pascal's Theorem and Brianchon's Theorem; The Theory of Pole and Polar; Metric Properties of Conics; Ruled Surfaces; Extended Theory of Projectivity; The Theory of Involution; Imaginary Elements; Foci and Focal Properties of Conics; and Planar Collineations.

J. S. GEORGES

DINOSAURS

A large cemetery of dinosaur bones has been found in the Kzyl-Kum desert, near the Aral Sea. An unusually complete succession of forms begins with small amphibians and ends with monstrous reptiles which were sometimes nearly 100 feet long.

These bones, as well as petrified trees also found here, indicate that in long past geological time this territory, which is now a desert, was rife with vegetation, Tass, Soviet telegraphic agency, states.

CHEMISTS ON VERGE OF DISCOVERIES THAT MAY CURE YELLOW FEVER, FOOT-AND-MOUTH DISEASE, INFANTILE PARALYSIS, INFLUENZA, NOBEL WINNER SAYS

A world free of four dread diseases and possibly a fifth as the result of work not by doctors, but by physical chemists, was boldly pictured by Dr. The Svedberg, world-renowned Swedish Nobel prize winner.

Mankind is on the verge of discovering how to dispose of yellow fever, infantile paralysis, foot-and-mouth disease, influenza and possibly cancer, Dr. Svedberg, in the United States to lecture as the first speaker on the Swedish Tercentenary Lecture program, asserted in an interview at the Princeton Club.

Filterable viruses, organisms so small that they are invisible beneath the most powerful microscopes in existence and that they pass easily through the finest porcelain filters, are certainly the causes of the first four ills and may be the cause of the fifth.

Filterable viruses have been found, he asserted, to be gigantic molecules of protein and not bacteria as formerly thought. The filterable virus responsible for tobacco mosaic, a disease highly destructive to tobacco plants, has already been isolated and its molecules studied by means of the ultracentrifuge which was invented by Dr. Svedberg and similar apparatus.

The ultracentrifuge, which consists of a tiny rotor driven by a blast of hydrogen and can rotate millions of times a minute, has enabled Dr. Svedberg and his colleagues to disentangle some of the complicated reactions occurring in substances found in the body and have enabled them to secure exact information on the sizes and shapes of molecules. Such knowledge, the chemist explains, is invaluable in working out methods of treatment.

"It is obvious," he concluded, "that we may expect soon to discover powerful weapons to fight illness and death through work along these lines."